Conceptualisation of a shared-regulated model in engineering collaborative learning environments

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Declaration

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed: 

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As per the regulations for submission according to the University of Strathclyde, I can confirm that I am the first author of all the above papers, responsible for all aspects of data collection, analyses, and reporting of the research.

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Abstract

In engineering education, teamwork is extremely common as it helps prepare students for their future professional careers. Additionally, groups are the perfect setting for students to deal with different situations, disagreements, shared responsibility, and discussions, all of which promote learning through collaboration. Even though teamwork is widely used in engineering education settings, supporting students adequately in their skills' development is difficult to achieve in practice. In some instances, there is an expectation that by the simple fact of having students to work in teams, they will develop these skills. In order to provide adequate support for students in developing their teamwork skills, there is a need to understand what metacognitive strategies they employ as a team, and how it is that they develop from these their team autonomy and, manage their own work in the team.

This research examines how two groups of six students of the third year of the chemical engineering program, work in a project-based learning environment. In their project, students must manage their own team effort, loosely supported by the tutor. The study uses as a body of naturalistic data, audio, and video footage of the teams while they work towards completion of a conceptual design project. The transcripts of the oral speech have served as the principal data corpus to conduct an inductive and deductive analysis to build a scheme model associated with the development of socially shared regulation of learning processes. The analyses of the data have identified key elements about the way students organise the different activities and tasks, manage their time, and deal with the different situations that could arise along with their meetings and the strategic approaches they have. The current results show that a shared-regulated scheme and a shared-regulated learning model have been proposed, incorporating some concepts that have been reported in the literature and conceiving others, which have been identified in the data corpus during the discussions and analyses.

These results help us understand how students manage their team themselves, in order to progress their team effort in completing tasks and achieving common goals.

The results are beneficial in considering the implementation of activities that support and foster student team's shared-regulatory behaviour.

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Contents

List of figures

List of extracts

List of tables

1. Introduction

This chapter describes the context of the research and the goals that have been set out. It also outlines the framework that has been used and served in the development of this thesis. A general structure for the thesis is presented at the close of the chapter.

1.1 Professional and life-long learning skills

With the rapid and unstoppable evolution of technology and current market conditions, humanity is facing more than even before unprecedented and increasingly urgent challenges (Anderson & Rainie, 2012), that need to be addressed and solved using reasonable solutions by well-versed professionals (Limberg, *et al*., 2021). Subsequently, teaching and learning are two of the most dynamic processes, which are powerfully influenced by the speedy changes that are taking place now across all the societal spheres (Tularam & Machisella, 2018).

As such, due to the fast evolution of technology, society is facing challenges that demand strong professionals with the appropriate skills, who can face these demands, while providing feasible solutions (Lucas, *et al*., 2014). In line with this continuous development, it is a fact that skills need to be kept up to date, as the tasks, methodologies, and activities are rapidly changing in any working environment (Singh, *et al*., 2018).

Therefore, the constant communication between professional bodies, industry, and Higher Education Institutions (HEI) has served as a crucial bridge to get significant input into key skills required (Kirby, *et al*., 2010). Hence, the role of HEI is vital in delivering the appropriate instruction per the current and forthcoming necessities of the world, shifting from siloed knowledge to mastering critical thinking, problem-solving, teamwork, and communication across disciplines; being these the most prominent transferable skills that have been reported as sought after as recent graduates tend to lack of (Succi & Canovi, 2020).

Then, new and innovative methods are being used in both, teaching and learning, to keep up with the rapid pace of change, including, but not exclusively, educating students with tools and cases, which are much closer to professional circumstances (Haleem, *et al*., 2022). Hence, the university could be seen as one of the ideal scenarios, where students can practice, or experience hands-on, using the latest developments and techniques to produce logical solutions to real problems (Lucas, *et al*., 2014); consequently, leading to empowering students to analyse, extract, and share meaning, ultimately generating valuable knowledge for society.

Furthermore, the term life-long learning has been extensively used in educational settings: it is defined as the attainments that an individual grasps since earlier ages until the very last years of his/her existence, and that has been strongly supported by many educators (Friesen & Anderson, 2004; Neely, *et al*., 2006; Laal & Salamati, 2012), who have highlighted the importance of specialised training once the formal education (i.e., school and college) has been accomplished (Billett, 2010; Kirby, *et al*., 2010).

Moreover, it is said that life-long learning is directly linked to the flexibility and ability of an individual to face new situations, as an imperative in a fast-paced and dynamic working environment (Barak & Levereng, 2016), which requires the development of life-long learning skills. Similarly, it has been claimed that self-regulation of learning fosters life-long learning, where learners are expected to trigger a series of skills and strategies, using them towards the achievement of a goal (Simons, *et al*., 2000; Lens & Vansteenkiste, 2008).

Additionally, learning is a continuous process that happens not only in academia but also in a great variety of places, such as technical events, seminars, workshops, conversations and discussions with peers, online platforms, and also the workplace (Kirschner & Hendrick, 2020); hence, context where it occurs is an important reference for any endeavour (Harris, 2013). Therefore, it is relevant to mention that, although learning happens in institutions of education, it cannot be only restricted to them. Yet, there is still a need to confirm the relevance of that knowledge and, most importantly, how this acquired knowledge is applied in a future working environment, while at the same time, meeting the needs of an ever-evolving market (Kirby, *et al*., 2010; Baker, 2023).

As a result, professional learning could be promoted and fostered by self-regulation of learning, where the adaptation process to new circumstances and constraints, in an ever-evolving workplace, occurs constantly as the market needs, technology development, and challenges emerge (Cleary, *et al*., 2022).

1.2 Supporting educational practices

In terms of learning processes, student-centred learning practices are teaching strategies that support the development of intellectual skills and autonomy through self-regulation, which can be ideally put into practice in a working environment (Dolmas, *et al*., 2005). As such, problem-based learning (PBL) is a methodology where students are exposed to problems that need to be solved, experiencing learning through the application of a series of strategies to come up with a feasible solution, that not necessarily is the only one, giving space to the development of problem solving and critical thinking (Matheson & Haas, 2010; Golightly & Raath, 2015).

Besides, in project-based learning (PjBL), as a variation of PBL, students are organised in small groups and are assigned a task, or presented with a scenario that needs to be solved in a specific time, providing them with some basic guidelines, giving them freedom to set their own goals, define roles within the group, and establish the time or deadlines to complete the tasks, or deliver a final product (Bate, *et al*., 2014; Kokotsaki, *et al*., 2016).

Therefore, problem- and project-based learning activities that are student-centred provide the perfect setting to investigate, and later describe, how shared regulation is displayed by the students in a group, working as a team towards a common goal under some constraints (i.e., not all the information is available, assumptions need to be made), and having to manage and organise a series of tasks and processes (Hadwin, *et al*., 2018). These two student-centre learning practices, PBL and PjBL, will be further explored and explained in sections 2.2 and 2.3 of this document.

Consequently, studies that have been executed in different learning environments, such as computer-supported collaborative learning (CSCL), virtual collaborative Research Institute (VCRI) learning, distributed learning, computer-mediate collaborative learning, and web-based learning environments, support the idea that shared regulation can be developed when student centred activities are deployed

(Järvelä & Hadwin, 2013; Malmberg, *et al*., 2015). However, more empirical evidence is needed to make a stronger and better description of the mechanisms and interactions, such as the perspective and negotiation of common goals, definition of strategies to succeed with the tasks, and evaluation of goal progress (Järvelä, *et al*., 2016); which ultimately will provide clear directions on how students can become aware of the regulatory processes that are taking place, and consequently, be able to adjust what could be out of track, or is not within a reasonable scope (Hadwin, *et al*., 2018).

1.3 Self- and shared regulation in teams

In the educational context, the ability to self-regulate our own learning is essential (Macaskill & Taylor, 2010). At this point, it is appropriate to say that in this thesis, as it has been described by Schunk and Ertmer (2000), self-regulation refers to the set of abilities to plan and monitor one's progress, which are fundamental for learners' progress towards building new capabilities and improving the ones they have already developed or inherited.

Individual self-regulation of learning has been studied over the years in a range of settings such as primary and secondary education (Zimmerman, 1990; 1995; Zimmerman & Moylan, 2009); this element has been lately revisited by Usher and Schunk (2018), who have offered some suggestions for future assessment of self-regulation in understudied learning settings (e.g., vocational training settings, higher education, distance education programs), where there has been a lack of evaluation and analysis.

As teamwork becomes commonplace in education, the need to study team regulation has become apparent, and models that include social and cognitive processes during teamwork have emerged (Järvelä & Hadwin, 2013). However, new empirical evidence is still required to develop models of shared regulation in groups (Schoor, *et al*., 2015). In this way, shared regulation is a phenomenon that occurs when groups regulate as a collective, such as when they construct shared task perceptions or shared goals (Järvelä & Hadwin, 2013).

Besides, it is crucial to make a clear distinction between autonomy and self-regulation in the educational context to avoid any future mix-up, as there is a tendency to confuse, or even use them interchangeably (Fabregas-Janeiro & Gaeta-Gonzalez,

2015). Autonomy is defined as the development of capabilities in students to enable them to become independent learners (Macaskill & Denovan, 2013); whereas, self-regulation refers to the self-directive process through which learners transform their mental abilities into task-related skills (Zimmerman, 2000), being this the distinctive element, the know-how to effectively progress and adjust their skills activity towards the completion of a task (Gross, 2015).

The project assignment, which will be presented and expanded later in section 3.2 of this document, has been used as a learning opportunity, serving to examine regulation of learning in teams, the elements connected to self-regulation in a team context, which are essential to understanding better how self-regulation takes place while students undertake an assignment or a task (Ellington & Dierdorff, 2013).

Equally, the project assignment has played a significant role as it has been the most important source for the construction of a model of student shared regulation in teams that reflects on the findings (Winne & Jaimeson-Noel, 2003). Likewise, there is a gap that needs yet more investigation, how team shared regulation is linked, directly or indirectly, to the enhancement of students' performance in the context of this research.

In addition, there is an evident necessity for the development of lifelong learning skills that could be easily, and ideally, transferred from an academic environment to a professional setting (Froehle, *et al*., 2022), and certainly among those skills, shared regulation of learning in the teamwork context in engineering programmes (Jaeger & Adair, 2018).

1.3.1 Self-regulation of learning and its correlation to PBL and PjBL

Figure 1.1 is a conceptual representation of the relationship and intertwined connection that exist among self-regulation of learning, when students are exposed to problem- and project-based learning centred environments, and the impact their implementation could have on the students' academic learning and professional life, when rightly applied and promoted.

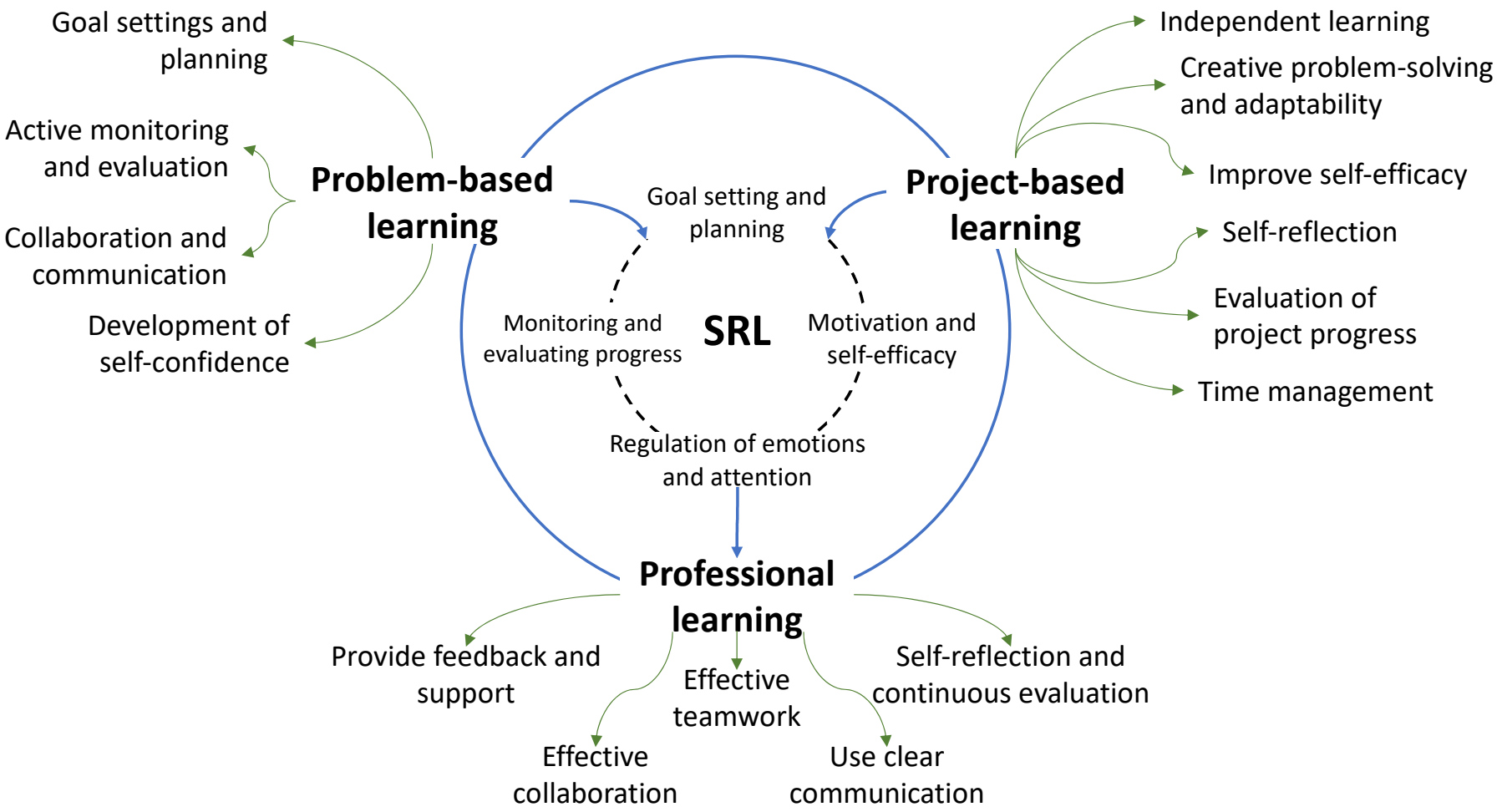


Figure 1.1. Relationship among SRL, problem- and project-based, and professional learning

At the core of diagram, self-regulation of learning lies, being the principal element that could be impacted and promoted by the implementation and practice of PBL and PjBL, which are located on the left- and right-hand side of the diagram, respectively; also, PBL and PjBL are accompanied by the elements that are associated to each of them, and that could be encouraged as a result of their promotion in these learning centres. At the bottom of the diagram professional learning is placed, accompanied by the elements that could be generated and impacted because of the successful implementation of such as learning centres environments.

Consequently, during the implementation of problem and project-based learning, students, who are exposed to and trained under their framework, could be directly benefited from them, as PBL and PjBL create ideal scenarios for the development of a series of skills such as goals settings, regulation of emotions, self-reflection, collaboration and communication, to mention a few of them; these skills, with the appropriate promotion, could turn into transferable ones that can be applied and used in a professional working setting (Almulla, 2020).

Therefore, skills that are stimulated through the implementation of PBL and PjBL are greatly wanted and required by companies more than ever before; skills that could help the future professionals be more prepared, ready for the challenges and needs of what the market demands to tackle its continuously requests (Lapek, 2018).

Shared regulation of learning as the starting point

The present study builds on the body of empirical evidence about shared regulation (Winne & Hadwin, 2008; Järvelä & Hadwin, 2013), focusing on project-based learning environments; thus, this work follows on from the work conducted by McQuade (2020) and Mabley (2020). In his work, McQuade (2020) has researched the floating facilitator PBL model, where learning is effectively tutorless, reporting actual social interactions in that learning setting, finely unpacking the conversational mechanics. And Mabley (2020), in her research, has evaluated problem-based learning on a curricula scale but without focusing on the collaborative processes involved in a student-centred and active pedagogy.

Subsequently, taking the latter work as the starting point is where this research has been conducted, concentrating on the actual interactional processes themselves, providing a richer description of the group shared regulation processes in teams of

engineering students, and how this is related to individuals' self-regulation. In addition, this study uses audio and video transcripts from students' project meetings during a one semester-long project as part of a chemical process design subject.

1.4 Research question

The research question addressed here is how students regulate their work as a group to fulfil their goals through the deployment of different tactics in the context of project-based learning. The emphasis of this study is in describing and analysing how shared regulation takes place within a group context, focusing the attention, especially, on verbal mechanisms alongside non-verbal cues as indicators of shared regulation displayed by the students.

Therefore, this question will be explored by collecting, describing, and analysing data using a qualitative method. A qualitative method offers the advantage of describing and analysing certain transactions that could occur in a group setting, where the continuous interactions and exchanges among the team members could lead either to the successful completion of a task or to an adverse outcome (Cohen, *et al*., 2011; Schreier, 2012; Braun, *et al*., 2019).

The need to understand whether autonomy is an ability that students develop, or a natural skill that simply emerges when they work with other peers in project group activities (Hadwin, *et al*., 2011) has not been deeply researched in the area of engineering education. This research will be looking at autonomous groups in a particular context – project-based work, as professional engineering work after graduation involves much in the way of group work, problem-solving and group project design, and management (Morgan, *et al*., 2013).

1.5 Objectives

This study aims to find how students at a group level, effectively develop autonomy while working in teams.

Along the development of this project the objectives that have been pursued are as follows:

- Identify and investigate, through the analysis of audio and video footage, how students use strategies to progress in achieving team goals.

- Examine the processes of group shared regulation to see what these might imply for the students' metacognitive and other skills at that particular juncture in their degree studies.
- Provide a conceptual model for socially shared regulation that builds on empirical evidence.

Thus, these objectives serve to convey an overall strategy with a specific focus on the exploration and identification stage of preliminary indicators, which are associated with shared regulation in the teamwork context.

1.6 Thesis structure

This thesis has been organised into seven chapters. The literature review, as **Chapter 2**, presents an examination of the theories within the literature that have generated the most empirical work in the area in recent years, and that are currently most prominent. As such, this chapter brings the background of proposed theories, teaching strategies and methodologies such as project-based learning, as the main one that has been used for the construction of this research, previous studies performed within a similar educational context, and the latest studies performed.

Chapter 3 provides a description of the research methodology and methods, explaining how the research has been executed, what approaches have been taken, and which practices and techniques have played a vital role when collecting, organising, and analysing the data.

The results and analysis parts have been organised into three different chapters:

Chapter 4 provides an insight into implicit and explicit elements associated with the identification of elements of self- and shared regulation.

Chapter 5, shared regulation in teams describes the elements of shared regulation in action, under two major components, Knowledge, and Processes, as they have been identified in the data.

The Discussion Chapter (**6**), offers the final analyses of the findings presented in **Chapters 4** and **5**, giving a detailed examination to the findings, their application in academic environments, and their potential for being further expanded to other settings.

Finally, conclusions of this research, limitations, implications for practice, and recommendations for future work are presented in **Chapter 7**.

2. Literature review

This chapter contains the background on the studies that have been conducted in education related to individuals and work in groups, and that have served for the conceptualisation of this research.

The chapter starts with a description of the theories that explain the learning process; then, it follows with the depiction of problem-based learning and project-based learning as the methods that have been paramount for this research. Subsequently, it introduces self-regulation of learning and the strategies that have been applied across different educational settings, which have fostered the development of regulatory skills through their implementation and practice.

Finally, it presents the coding scheme for the analysis of socially regulated learning, bringing its main elements and implementation, closing it with the activities that support the promotion of self-regulation.

2.1 Learning theories

In the educational context, there are theories and concepts that have been used to explain and dissect the way people learn (Edgar, 2012). They are the cornerstone for educational practice, providing frameworks and insights into how individuals acquire knowledge, skills, and behaviours. Also, learning theories offer educators a deeper understanding of the learning process, guiding the design of effective instructional strategies and interventions. From classical to contemporary perspectives, learning theories encompass diverse approaches, shedding light on the complex dynamics of learning (Stewart, 2021).

Classical learning theories, such as behaviourism, focus on observable behaviours and the role of external stimuli in influencing and shaping learning outcomes. Behaviourists suggest that learning is the direct result of responses to stimuli in the environment. Pavlov, Watson, and Skinner pioneered behaviourism (Bredo, 1997).

Pavlov (1903) conducted experiments involving dogs and bells, illustrating how animals could be conditioned to exhibit particular behaviours through exposure to a neutral stimulus, resulting in the classical conditioning principle (VanElzakker, *et al*., 2014). As a result of this finding, John B. Watson (1913) extended it to human learning, with association getting recognition as a fundamental aspect of daily learning, it emerged as a key factor in shaping perceptions and phobias. For instance, the fear of exams is not inherent; rather, it arises as a conditioned response to past negative experiences (Stewart, 2021).

Skinner (1938) expanded the concept of animal and human conditioning upon introducing modifications and additional reinforcement stimuli, breaking down tasks into smaller segments, and employing sequential methods with positive rewards and negative sanctions These methods were utilised to illustrate how certain behaviours could be moulded and strengthened towards desired outcomes (Woollard, 2010).

Furthermore, Skinner's experiments established another principle of learning, which has been referred to as instrumental or operant conditioning (Jozefowiez & Staddon, 2008). Correspondingly, behaviourism emphasizes conditioning and reinforcement as mechanisms for learning. In the educational context, behaviourist principles underscore practices such as reward systems, drill-and-practice exercises, and behaviour modification techniques (Woollard, 2010).

Consequently, behaviourism incorporates key concepts such as conditioning, referring to the process of strengthening a natural reflex or any other behaviour triggered by a specific stimulus; reinforcement, related to anything that has the effect of strengthening a particular behaviour, increasing the likelihood of its recurrence (Phillips & Soltis, 2009); punishment, a controversial concept, whether its effectiveness to reduce certain undesirable behaviours through the application of an unpleasant follow-up, that could generate the opposite, anger, frustration, or even aggression; and shaping, a technique used to manipulate both animal and human behaviours by incentivising actions they have never naturally exhibited (Pritchard, 2009).

In practice, behaviourist approaches in education often involve structured instruction, repetition, drills, and rewards for desired behaviours; besides, educators accompanied the practice of such as approaches with the application of positive

reinforcement, including praise or rewards to encourage desired behaviours, and also, negative consequence for undesired behaviours (Woollard, 2010).

Cognitivism is another learning theory that focuses on the internal mental processes and structures that are involved in learning, such as attention, memory, and problem-solving (Bredo, 1997). Unlike behaviourism, which emphasizes observable behaviours, cognitivism emphasizes the role of cognitive processes in understanding how learning occurs (Muskett, 2019).

In the educational context, cognitivism suggests that learners actively process information, make connections between new and existing knowledge, and construct meaning from their experiences. Piaget and Vygotsky have emphasized the role of cognitive development and social interaction in learning, where learners actively construct knowledge through processes such as schema formation, involving activities that promote critical thinking, problem-solving, and metacognition (Ertmer & Newby, 2013). Hence, educators may use strategies such as scaffolding, modelling, and guided practice to support students' cognitive development (Pritchard, 2009).

Furthermore, cognitive psychologists have developed the concept of schemas to refer to a mental framework or structure that organises and interprets information. These schemas are built through experiences and serve as the foundation for understanding and processing new information. According to cognitivist theories, learners actively construct and revise their schemas as they engage with new knowledge (Watson & Coulter, 2008).

As such, in the education context, the understanding of the schema concept is crucial since it highlights the importance of prior knowledge and its direct influence on learning (Riso & McBride, 2007). Educators can use this concept to design instruction that builds upon students' existing schemas, helping them make connections between new information and what they already know (Pritchard & Woollard, 2010).

Besides, in recognising that learners may have different prior experiences and backgrounds, educators can employ strategies to activate and scaffold students' existing schemas to facilitate deeper understanding (Phillips & Soltis, 2009). By acknowledging the role of schema in learning, educators can design more effective instructional practices that promote meaningful learning experiences for all students (Pritchard & Woollard, 2010).

Constructivism represents another paradigm shift in learning theory, emphasizing the active role of learners in constructing their understanding and knowledge within social and cultural contexts. Bruner and von Glasersfeld highlighted the importance of learners' prior experiences, perspectives, and interactions in shaping their understanding of the world (Oleson & Hora, 2014). Constructivism suggests that learning is a process of meaning-making through interactions with both the environment and social interactions with others (Pritchard & Woollard, 2010).

In the educational context, constructivism promotes hands-on, inquiry-based learning experiences that allow students to explore, experiment, and discover knowledge for themselves (Pritchard & Woollard, 2010). The prevailing notion suggests that individuals actively construct their own knowledge instead of passively receiving it (Oldfather, *et al*., 1999). An aspect that has been highly debated is whether students are primarily taught by educators, who are seen as the main agents in the process, or whether students themselves are the ones who construct their own knowledge. Moreover, if the students are the ones who construct it, their experiences are so unique that it is hard to measure it, or at least, establish certain reference evidence of it (Tokuhama-Espinosa, 2010).

In constructivism, teachers function as facilitators or guides, providing opportunities for students to engage in authentic tasks, collaborate with peers, and reflect on their learning (Bransford, 2000). Constructivist approaches often involve projects, discussions, and other activities that encourage students to actively construct their understanding of concepts, rather than passively receiving information. (Oldfather, *et al*., 1999)

Social constructivism builds upon constructivist principles by emphasizing the collaborative nature of learning and the role of social interactions in the construction knowledge (Pritchard & Woollard, 2010). Vygotsky's socio-cultural theory posits that learning occurs through interactions with more knowledgeable others, such as peers, teachers, and mentors (Jaramillo, 1996). In educational settings, social constructivism informs practices such as cooperative learning, reciprocal teaching, and communities of inquiry, fostering shared understanding and collective knowledge-building (Phye, 1997).

By recognizing the social and interactive nature of knowledge construction, social constructivism provides a powerful lens through which to conceptualise learning as a

collaborative, contextual, and deeply situated phenomenon (Marton & Booth, 1997).

On the other hand, Bandura argues that people learn by imitation of others, emphasizing the importance of observation, imitation, and modelling in learning. He has argued that individuals learn not only through direct experience, but also by observing others, especially those they perceive as role models. A theory that challenged the behaviourist view that learning is solely a result of reinforcement (Jordan, *et al*., 2008). This expanded framework emphasizes the role of cognitive processes, including attention, memory, and motivation in learning and behaviour, highlighting the importance of self-regulation and self-control in shaping behaviour (Mimiaga, *et al*., 2009).

Bandura also introduced the concept of self-efficacy, which refers to an individual's belief in their ability to accomplish tasks and achieve goals. He argued that self-efficacy plays a crucial role in determining behaviour, motivation, and perseverance in the face of challenges. High self-efficacy is associated with greater effort and persistence, while low self-efficacy can lead to avoidance and decreased performance (Sutton, 2001).

One critical concept within social constructivism is the notion of the zone of proximal development (ZPD). ZPD has been coined by Vygotsky, and it refers to the difference between what a learner can accomplish independently and what they can achieve with the guidance and support of a more knowledgeable individual, such as a teacher, peer, or mentor (Roth, 1999); aspects that are exemplified in figure 2.1.

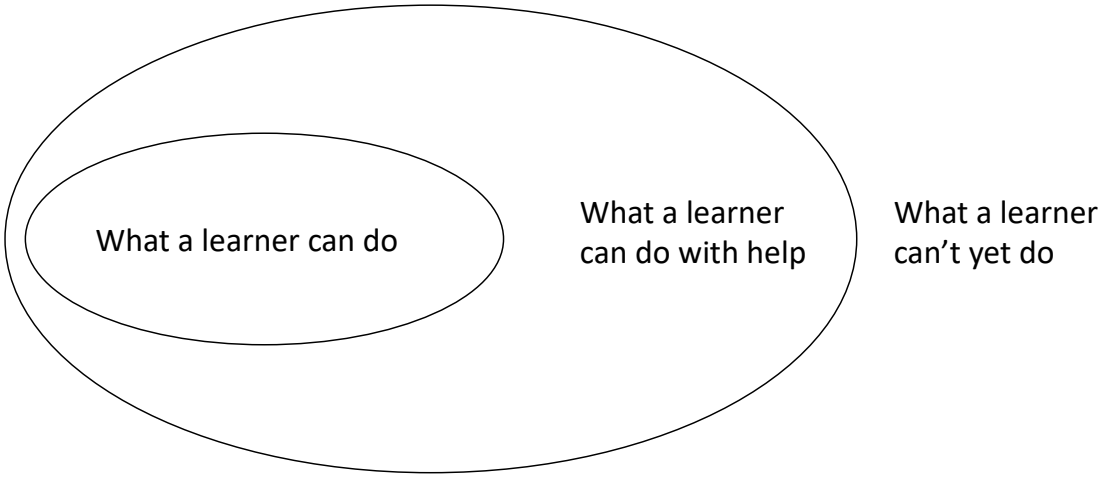


Figure 2.1. Vygotsky's *ZPD* – Adapted from Kalantzis and Cope (2012)

The ZPD concept emphasizes the dynamic nature of learning, as learners progress from dependence on external support to greater independence and mastery. It underscores the role of social interaction, dialogue, and collaboration in facilitating cognitive growth and development (Gauvain, 2020).

ZPD highlights the importance of social interaction and collaboration in the learning process, instead of focusing solely on what learners can already do on their own (Simon, 1999). As such, educators should identify and scaffold activities and tasks that lie within the students' ZPD (Säljö, 2010). By providing appropriate levels of support and guidance, educators can help learners navigate challenges, develop new skills, and understanding (Walker, 2010).

In educational practice, understanding the ZPD informs instructional strategies such as scaffolding, peer tutoring, and collaborative learning experiences. By tailoring instruction to learners' individual ZPD, educators can optimize learning opportunities and promote meaningful engagement and growth (Matusov, 2001).

Connectivism represents a contemporary perspective on learning that acknowledges the influence of digital technologies and networked environments (Cleary, 2020). Proposed by George Siemens and Stephen Downes, connectivism posits that learning is distributed across networks of people, resources, and technologies (Renda & Kuys, 2015). Learners navigate these networks, engaging in activities such as information seeking, knowledge creation, and networked collaboration (Bennett & Szedlak, 2023). In the digital age, connectivism principles inform approaches like online learning, personalised learning pathways, and networked pedagogies that harness the power of digital connectivity (Corbett & Spinello, 2020).

In summary, learning theories in education encompass diverse perspectives that illuminate the complexities of the learning process. From behaviourism to connectivism, these theories provide valuable insights and frameworks for educators to understand, facilitate, and optimise learning experiences for diverse learners in various contexts. By integrating principles from multiple theories, educators can cultivate dynamic, inclusive, and effective learning environments that empower learners to thrive in the 21st century (Mensah, 2015).

Having presented the learning theories, the subsequent sections will introduce problem-based learning and project-based learning, which are both instructional

methodologies deeply rooted in constructivist theories of learning, particularly social constructivism (Benson & Brack, 2010).

2.2 Problem-based learning

Problem-based learning (PBL) is one of the educational methods applied in academia, where students face problems at first hand, learning through the experience of solving a problem, thinking about feasible solutions while getting a better understanding and knowledge that can be further applied in a real environment (Matheson & Haas, 2010; Golightly & Raath, 2015).

PBL has been extensively used in medical education, where it was started and has been broadly applied, making significant developments and adaptations to their lecturing strategies (Barrows & Tamblyn, 1980), with the creation of medical cases that were closer to those to be faced in a working environment, directing the students towards scenarios that could help them develop and build essential skills, such as problem-solving and disciplinary knowledge, when dealing with similar situations, or even more complex ones (Brassler & Dettmers, 2017). Likewise, PBL has been applied in engineering programs, and has also been used in the teaching of other subjects (Shuler, 2012; Edström & Kolmos, 2014; Kolmos, 2017).

Furthermore, PBL has been broadly used in schools and institutions of higher education (Schmidt & Moust, 2000; Savin-Baden, 2003; Jonassen & Hung, 2008), where students normally work in groups, and complex and not well-structured challenges need to be solved, and they do not necessarily have one right solution (Simons, *et al*., 2004; Schmidt, *et al*., 2011). Thus, students actively explore real-world problems and challenges, while acquiring deeper knowledge (de Graaf & Kolmos, 2003; Lam, 2009), boosting their commitment with the use of deep engagement from students and tutors for its successful implementation (Dolmas, *et al*., 2005).

Besides, in problem-based learning a defined problem is used as a preliminary point of the learning process. Typically, in PBL the problem is outlined according to the specific learning needs, where they could be based on real-life problems to meet the educational purposes, and potentially be solved using investigation, explanation, and resolution (Jonassen, 2011). Also, it could be the case, where the scenario is hypothetical so the basis of the mechanics could be explored and learned by the students (de Graaf & Kolmos, 2003).

De Graaf and Kolmos (2003) have distinguished two models in educational PBL practices: problem-based and project-organised learning. In project-organised learning, they have pointed to the fact that the scope (breadth and complexity) of the project (problem-based) can determine the level of student involvement.

In PBL students usually work in groups to identify what they need to learn and to produce a realistic solution to the problem, allocating tasks to each team member, and monitoring progress towards a common goal (Jonassen, 1997). Therefore, educators have been especially keen on using PBL as it has made a strong emphasis on effective, transferable learning, and it is prospective as a starting point of student's learning (Gijbels, *et al*., 2005). As such, the role of the educator is to serve as facilitator to the process and guide students through the learning cycle (Savery, 2019).

According to Savery (2019), students that have been exposed to PBL have received a much stronger preparation for their professional lives, where integrating theoretical concepts with practical skills can be applied to address real problems in a working environment; an important element, given the needs of the job market, which demands a series of skills that could be ideally acquired in the academia and be transferred to a professional setting (de Prada, *et al*., 2022). Also, the development of metacognitive abilities such as planning, monitoring, evaluation, and adjustment under PBL, has been linked as key learning outcomes (Strobel & van Barneveld, 2009).

2.2.1 Problem-based learning in the educational context

Hmelo-Silver (1998; 2002; 2004) has applied and comprehensively researched problem-based learning, implementing a series of practice strategies along her research. There is an important element that has been noted in Hmelo-Silver's (1998; 2002; 2004) research and is how PBL has been centred around certain goals that support the construction of an extensive and flexible knowledge base (Schmidt & Moust, 2000), such as the development of effective problem-solving skills, being this one the most specific claimed value of PBL.

Furthermore, Hmelo-Silver's (1998; 2002; 2004) practices have reinforced the development of self-directed and lifelong learning skills, become an effective collaborator and intrinsically motivated to learn (Barrows & Kelson, 1995), which could

be seen as essential to foster self- and shared regulation, and are at the core of my research.

Through observations, students' surveys, and interviews, Hmelo-Silver (2004) has gathered and built significant evidence that supports the practicability that PBL has had on students' performance and preparation for their future careers. Subsequently, these results have been grouped under five areas that have been asserted to be impacted by PBL:

1. *Constructing extensive and flexible knowledge*, referring to the fact that PBL prompts the development and acquisition of concepts that could be potentially applied in real situations; this has been supported through practices in medical students, specifically, when comparing the results of groups of students, who have been trained using traditional methods to those, who have been taught under PBL, showing a much stronger performance of the latter. This assertion has been attributed to the fact that when people are trying to learn something new or apply a new knowledge, there is a normal tendency to make mistakes, which seems to be a vital step (Chi, *et al*., 1994), and that certainly could be considered a reflex of acquiring new knowledge, or at least, experiences that could somehow be useful when applying recent concepts and ideas in practice.
2. *Developing effective problem-solving skills*; this might be seen as the most claimed effect and benefit that PBL could have on students who have been exposed to it. It has been seen in certain teaching environments that students could develop and transfer tactics to solve new problems (Newell & Bain, 2018); however, there is still the need to conceptualise or devise a way or method that could assure that this in reality happens as a result of PBL (Lee, *et al*., 2018).

Also, it has been reported in studies that when comparing results of tests applied under traditional curricula to those carried out through PBL, the difference between them tends to be minimal (Dochy, *et al*., 2003), which raises the question if it is worthy all the preparation and effort that is invested when implementing PBL, given such a contradictory outcome.

3. *Developing self-directive learning skills*; one of PBL advantages is that it offers the framework for students to build up, adapt, and adjust their own strategies to learn a topic or concept; and it is here, where PBL could foster independence while giving learners strategies that could be adjusted to their needs and demands (Evensen, 2000).

4. *Becoming effective collaborators*; students in PBL usually work in groups, thus, the interaction of the members is key for the success of the group as an entity (Mohd-Yusof, 2017). It has been seen that collaboration is not always an easy aspect to deal with across groups; this has been the case when members tend to be loafers, and cooperation among team members tends to be less effective than expected due to disparities among them (McQuade, *et al*., 2020).
Nonetheless, when collaboration is active, there is a strong leading to knowledge construction, which has been the case when students join in focusing and refining concepts or ideas that have been proposed in a teamwork setting (Hmelo-Silver, 2002), and aspect that is relevant when the need of consensus and deliberation to reach agreement is imperative for the completion of a task or activity.
5. *Becoming intrinsically motivated*; improvement of internal motivation has been claimed as one of the most significant advantages of PBL. Fundamentally, internal motivation emerges as the determination to solve a problem is kept and encouraged by the confidence and drive to solve the task, where the challenge that is yet to be faced might pose the necessary elements to power up the stimulus (Derry, *et al*., 2000). Nevertheless, this factor has been hardly measured, as it could be associated a certain level of self-reflection linked to the motivation to move on or succeed while completing a task or challenge.

Furthermore, PBL has had evaluation studies, examining how well it promotes student learning, and clearly demonstrating that it does indeed do so (Kjersdam & Enemark, 1994; Kolmos, 1996; Servant-Miklos, *et al*., 2019). However, to understand exactly how these learning gains are happening, there is a need to look not only at learning improvements, but at group processes taking place within PBL sessions, which is where this research is looking at shared regulation processes within project-based learning sessions using a qualitative approach.

Hmelo-Silver (2004) has conceptualised a cycle that is commonly followed in PBL, and that is shown in figure 2.2. The cycle starts with the analysis and the identification of the facts that are embedded in the project, being considered a key stage of the process because students are expected to make a representation of the problem and see how it could be oriented towards a solution path.

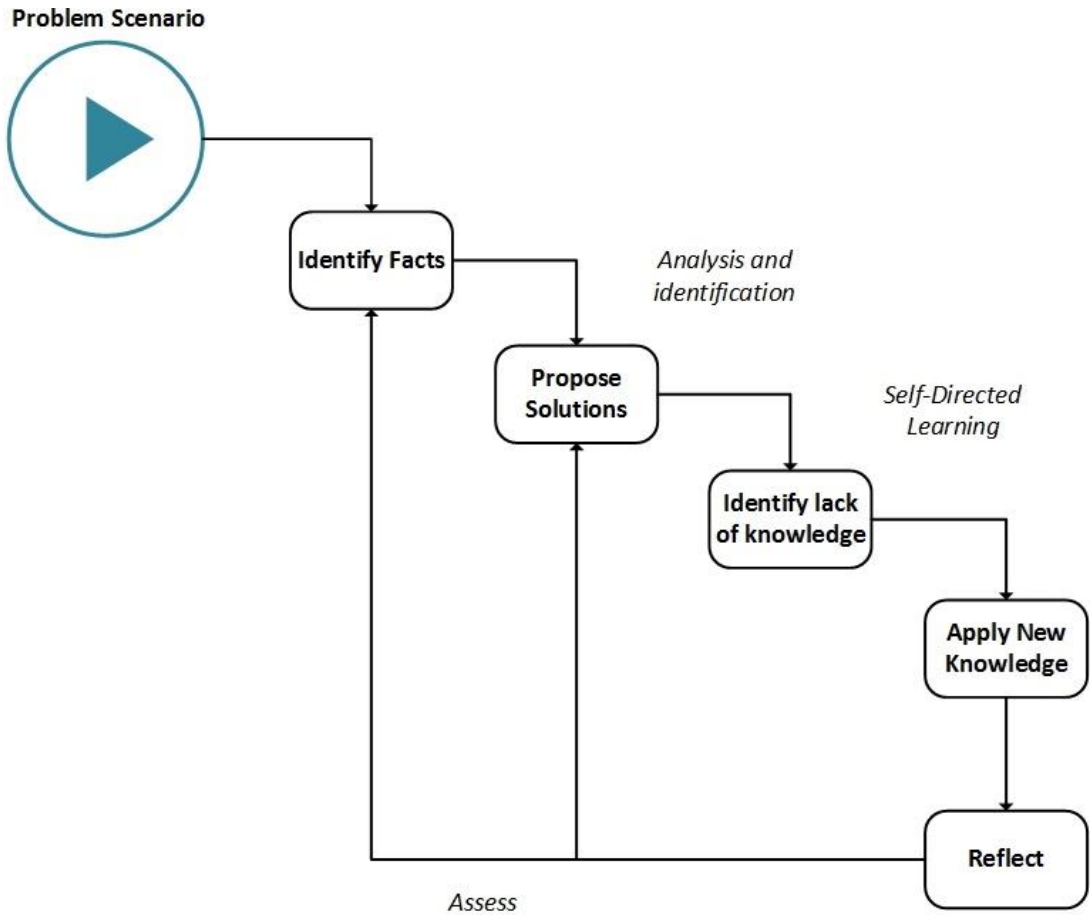


Figure 2.2. Problem-based learning cycle – Adapted from Hmelo-Silver *(2004)*

Once the students get a better understanding of the problem, they are expected to come up with potential solutions, or at least, a clearer idea of what is being asked for (Schmidt, *et al*., 2019). However, as it has been stated by Hung *et al.* (2019), it is natural that as part of the learning cycle, students struggle to find solutions due to first, the lack of knowledge, and second, expertise to approach the tasks. As a result, these knowledge deficiencies turn into what is known as learning problems that are part of the self-directed learning, which is seen at the core of PBL, and that according to Schmidt *et al*. (2009) is what PBL should aim for, students develop the ability to regulate their learning so to progress in their academic journey.

At this point of the cycle, students usually apply previous knowledge, and ideally, the new one that has been acquired after their individual reading and other academic study, assessing the feasibility of their solutions according to what they have obtained and the reasonability of them (Leary, *et al*., 2019). Once the cycle reaches an end, students reflect on what they have learned, mostly evaluating the identification of facts

and the solutions proposed, to later establish, what has worked well and what could be improved for the upcoming tasks (Hmelo-Silver, 2004). Reflection could be seen as the most important stage for this research, as it serves as the catalyser for the self- and shared-regulation elements development of the learning process (Ryan & Deci, 2009).

Nevertheless, reflection is an element than although its prevalence and importance in the academic context has been hardly reported, as students tend to avoid being critic of their own progress, especially in big groups, when the number of group members is greater than three, needing the presence of a facilitator who can support the process.

Additionally, in the context of teamwork, Northwood *et al*. (2003) have studied the application of PBL in health sciences and engineering programmes, with the aim that the student's learning is a direct result of diverse working processes towards the comprehension or solution of a problem. In doing so, teaching methods such as research projects, case methods, and design projects, among others, have been used in small groups of students, around 5 to 10 members, with the support of a tutor, and even, tutorless groups.

As a result of Northwood *et al*.'s (2003) studies, it has been claimed that PBL prioritises the process of learning over traditional teaching methods. Hence, PBL highlights that learning is not a passive absorption akin to filling a glass with water; rather, it is an engaging endeavour driven by learners' curiosity, interests, and experiences.

Consequently, a PBL goal is to foster active investigation and creation, ultimately leading to the development of deeper insights, expanded knowledge, and enhanced skills; aspects that could be similar to the setting and design of the project development used for my research, where potentially, the group processes and facilitations skills could be developed from inwards; thus, students would lead their own group by themselves (Wood, 2004).

On the other hand, Northwood *et al*. (2003) state that graduates who have undertaken a PBL program would possess enhanced readiness for the evolving workplace environment, claiming that these professionals, with a capacity for self-guided and continuous learning, would contribute significantly to their workplaces by their

adaptability to shifts and their capability to bolster their companies' competitiveness in a global arena; nevertheless, there is a lack of specific evidence or data to support such a claim, that graduates from PBL programs are inherently more adaptable or better suited to the changing nature of the workplace compared to graduates from other educational approaches.

Overall, PBL, informed by social constructivism, offers a valuable approach to education, but careful planning, skilled facilitation, and critical reflection are essential for its success. Its solely implementation without the incorporation of specific adjustments based on the students' learning needs and expected outcomes, could limit its success with potential student's aversion to work under the PBL umbrella (Markula & Aksela, 2022).

2.3 Project-based learning

Project-based learning (PjBL) is a learner- and opened-centre approach that aims to accentuate the student's independence and teamwork by creating a constructive collaboration that has the potential of solving a problem, with the creation of a product (Brassler & Dettmers, 2017; Warr & West, 2020). PjBL encompasses a series of goals that aim to help students develop knowledge and skills that can be used across different subjects, for effective problem-solving and for collaboration (Dolmas, *et al*., 2005; Guo, *et al*., 2020).

Similarly, project-based learning (PjBL) is also referred in the literature to describe a methodology that combines learning process around projects (Thomas, 2000) with professional skills development, disciplinary knowledge, and independent and flexible learning, while accommodating a wide range of students' learning needs (Warnock & Mohammadi-Aragh, 2016), with the generation of a genuine product or outcome at the end (Kolmos & de Graaff, 2014; Tan & Chaptman, 2016).

PjBL as a centred approach is one of the perfect scenarios where the combination of professional skills development, disciplinary knowledge, organisation skills and independent flexible learning takes place, preparing students for future learning needs and making the way of the future professionals (Rooij, 2009; Graham, 2010).

Furthermore, PjBL has been used by teachers and lectures in schools and institutions of higher education (Rooij, 2009; Capraro & Jones, 2013; Pryor & Kang, 2013),

respectively, where project-based learning has played a central role through the completion of genuine tasks, which in most of the cases, have been built based on personal interests of the students (Grant, 2011).

2.3.1 Project-based learning research experiences

As one of the cases where PjBL has been applied, Dole *et al.* (2016) have conducted and implemented, for example, studies using PjBL with a group of K-12 students – which would be the equivalent to S6 of the Scottish Education System – in an American school.

Students, who have participated in the activity, had previously registered their interest as its attendance was not compulsory. Topics of the projects were allocated based on the interest showed by the participants, ranging from novel innovations, spy and espionage, digital storytelling, crime scene investigation, and costume creator's guild, to topics that could be more challenging and advanced such as show off with animation, robotics, and amateur aeronautics, to mention some of the great arrays of areas.

During the week that the project took place, students worked in groups of around six members, where they decided to choose a problem, or a project related to the group topic. Groups were intended to work from 10:00 until 16:00; on the first day of the activities, students were brainstorming, locating the resources they could need to use, and planning a timeline for the activities for the week.

Also, teachers and staff were available to help and guide the students in the case they might require doing so. By the end of the day, teachers involved in the activities met to reflect on the development of the activities, challenges and difficulties faced along the day. In the final day of the project week, Friday, students were expected to present their products to an audience, that usually included their parents and teachers.

As a result of the study, Dole *et al.* (2016) have reported that skills such as problem-solving, student collaboration and real-world connection, as the most prevalent, were boosted because of the activities that had been undertaken along the project conception, development, and completion. Furthermore, it was noticed how students self-assessed their progress, given the fact that they had set a timeline at the start of

the week for their own activities and project completion, that potentially could serve to regulate their interests and ambitions.

The previously stated could be seen as one of the most important outcomes of any PjBL implementation, when the individual develops the ability to evaluate their own progress, leading to the improvement and refinement to self-regulate and adjust their performance for any upcoming task or project.

In addition, abilities such as creativity, divergent thinking, and open-mindedness were stimulated throughout the accomplishment of the challenges. Likewise, it was informed that students had learnt to ask more elaborate questions and make observations so they could identify issues that needed to be addressed.

The statement that students have learnt to ask more elaborate questions and make observations to identify issues that need to be addressed is indicative of a positive shift in their learning approach. This development suggests a move beyond rote memorisation or passive absorption of information towards a more active and engaged form of learning.

One key aspect of this transformation is the emphasis on critical thinking skills. By encouraging students to ask elaborate questions, educators are fostering a mindset that goes beyond merely accepting information at face value. This skill is crucial in today's complex world, where challenges often required nuanced understanding and innovative solutions. The ability to formulate thoughtful questions indicates a deeper engagement with the subjects, fostering a more profound comprehension of the material.

Moreover, the mention of students making observations implies a move towards experiential learning. Learning through observation allows students to connect theoretical knowledge with real-world scenarios, enhancing their ability to apply concepts in practical solutions. This approach not only aids in the retention of information but also promotes a holistic understanding of the subject of interest of the students.

However, the study raised the question of whether this shift in learning approach is consistent across various subjects and disciplines. While it may be evident in some areas, ensuring a holistic integration of these skills across the curriculum is crucial for a well-rounded education. Also, a careful consideration should be given to the

supporting teaching methodologies and evaluation strategies to ensure the sustainability and effectiveness of this educational transformation.

Additionally, PjBL has been implemented across universities but with a higher level of demand, and according to the educational stage of the students (English & Kitsantas, 2013) . This has been the case of Brassler and Dettmers (2017), who have carried out a PjBL implementation through an observation-analysis during three semesters in German universities.

Students, who were attending the course, came from different programs across the university offer and were attending their fifth semester of their program; thus, groups were made interdisciplinary, including those coming from psychology, economics, pedagogics, law, and mechanical engineering programs, to mention some of them.

During Bassler and Dettmers' (2017) study, five courses were analysed, which implied 48 groups in total, and who had been working in a semester project-related assignment. In addition, while students met in their classrooms, researchers visited them four times during the semester, observing how they worked, talking to some group members and with the subject lecturers.

As part of the study, two surveys were conducted to the participants, at the beginning of the project and at the end of it, where the aim was to identify the strengths and weaknesses of the team members, establishing a comparison point so any skill improvement and lack of some abilities could be recognised.

Given that the group members were from diverse programs, there was great variety of project topics to choose from, ranging from the creation of a flea market to raise money for a social cause, to the development of a project policy program for nuclear power countries, the edition of a book on sustainable nutrition, development of a successful strategy for immigrant workers, and even the creation of an inclusive urban gardening project. At the end of the semester, students were evaluated based on the quality of the report, the integration of the different subjects, the usability and applicability of their product.

By the end of the study, it was concluded that skills such as project solving, collaboration and communication in an interdisciplinary setting were positively impacted through the application of project-based learning. It was also reported that there was an enhancement of students' understanding of having and using diverse

perceptions when developing suitable solutions. The assertion goes further to highlight the reported enhancement in students' understanding of diverse perspectives during solutions development, which in turn, could boost a much higher interaction between student-lecturer; consequently, critical thinking might be encouraged if what it is received as input or clues from the lecturer challenge students' assertions.

Moreover, the projects have also served to approach the students to a very realistic working environment, where professionals from diverse backgrounds, preparation and seniority would work towards a product, as the topics were real and relevant to their educational formation. The emphasis on an interdisciplinary setting adds depth to the analysis, interdisciplinary collaboration is increasingly recognised as indispensable in addressing complex challenges; hence, implying that PjBL could be particularly effective in encouraging skills such as real-world problem solving, collaboration, and communication within this context.

Also, the interdisciplinary aspect is especially noteworthy in a globalised world, where diverse perspectives could contribute to innovative solutions. However, it raises questions about the generalizability of the findings, as the effectiveness of PjBL may vary across different interdisciplinary domains.

Furthermore, Fernandes (2014) who has used and applied PjBL as part of her teaching practice, has reported how project-based learning supports the student's readiness for professional practice. This has been based on a three-academic project implementation research, where it has been argued that the framework of PjBL allows for a direct connection between theory and practice to be established, given the fact that the projects faced are, in their great majority, real ones or close enough to those in a real working context.

In addition, it has been noted that one challenge students face is the perceived heavy workload, which can become an increased burden when not all team members contribute equally (Fernandes, 2014). An aspect that could have the potential of undermining the effectiveness of PjBL, as students, who are more passionate about their learning process, might feel discouraged to participate and engaged enthusiastically, if not all team members undertake similar workloads; aspect that has been studied and reported by McQuade *et al.* (2020), presenting the challenges that

teamwork brings, especially, when working in groups some team members tend to be social loafers, not putting the same effort towards the task or activity completion.

The present work has used a wide scope project (i.e., broad and complex); therefore, this study will be focused on the use of project-based learning, making a distinction here between project-based learning and more general problem-based learning.

Project-based learning has been shown to be effective for learning (Helle, *et al*., 2006), but to find out precisely why and how, it is needed to have a qualitative review of group processes within PjBL, where the examination of students' interactions is the natural point of exploration.

Similarly, it is said that PjBL supports and promotes the self-regulation process, due to the nature of the learning progression while students are constructing mental representations for giving feasible solutions to address a diverse type of problems (Zimmerman, 2008; English & Kitsantas, 2013).

Consequently, an important area for further exploration is the self-regulation processes that groups use in project-based learning, as these finer details have not yet been fully unpacked.

2.4 Self-regulation of learning

Self-regulation of learning (SRL) refers to the process as the self-generation of thoughts and emotions, which are applied methodically and strategically as required to generate an effect on the learning process (Meece & Painter, 2009).

It has been defined that self-regulation is based on three essential components, metacognition, cognition, and motivation (Sinatra & Taasoobshirazi, 2018). For the former, this includes the knowledge and regulation needed for understanding and controlling one's cognition; for cognition, it considers the necessary skills such as problem solving, inquiry, and critical thinking that are required to solve a problem; and for the latter, it centres on the attitudes and beliefs that impact the effective application and improvement of the other two components, cognition and metacognition (Winne & Perry, 2000).

In addition to the three already mentioned components, it has emerged a fourth factor, emotions, which seems to have direct implications onto how students learning could be motivated by positive or negative stances; where positive emotions towards a topic

or task could motivate and support attitudinal and conceptual construction of knowledge, a greater engagement, thus, better grades (Pekrun & Stephens, 2012), and the opposite effect, that could potentially lead to aversion for the subject, disengagement, lack of interest, and lower grades (Heddy, *et al*., 2017).

Furthermore, the study point outs that the presence of misconceptions, negative emotions, and unfavourable attitudes within individuals can be effectively addressed through conceptual change. The observed shifts in attitudes appear to be mediated by concurrent emotional changes. This implies that interventions aimed at promoting conceptual change not only contribute to altering individuals' knowledge, but also exert a positive influence on their emotional states and attitudes. This insight holds particular significance in the context of subjects that challenge individuals' existing beliefs, particularly those within the realm of science, where emotional and attitudinal components are frequently pronounced.

The studies and analyses executed by Schunk and Ermet (2000), Winne and Perry (2000), Grant (2011), and Gross (2015) have provided solid frameworks that support and explain the different processes taking place during the self-regulation of learning; besides, they have enlightened elements such as problem-solving skills, awareness and control of conceptual knowledge, critical thinking, reasoning, pertinent strategies for success, that are essential for scientific proficiency, and which students could apply to the regulation of their own learning (Anderman, *et al*., 2012; Asterham & Schwarz, 2016).

When students are dealing with an assignment, tasks, or even projects, it is well known that they normally require the continuous support of a tutor, who can give them indications or provide insights that could lead ideally to the successful development of the work (Hmelo-Silver, 2004).Therefore, there is a persistent need for schooling students in strategies such as asking questions, goal setting, scheduling and managing time, asking for assistance when they feel confused, outline, diagram, review, summarize the information, arrange the environment, paraphrase, observe, analyse data, interpret the evidence, reinvent, and adjust the practices according to their needs.

As a result, all of these strategies aim to reach a point where the support and intervention of the tutor could be less, resulting ideally in greater student independence; thus, self-regulation and autonomy become the rule (Reeve, *et al*.,

2008; Macaskill & Denovan, 2013); consequently, such strategies could ultimately support and foster the independence of the students while working on an assignment (Corno, 2008; Winne, 2004; Winne & Jaimeson-Noel, 2003; Wood, 2004).

The subsequent sections bring some studies that have been done having as the main focus self-regulation of learning, its implications and applications, presenting the most significant and relevant models that have been conceptualised and proposed.

2.4.1 Self-regulation as a teaching and learning tool

Lopez *et al.* (2013) have explored the study strategies that are used by first-year organic chemistry undergraduate students in an American university. For their study, they have used three strategies that students commonly use: weeklong study diary, problem sets, and concept maps for the evaluation of self-regulated learning strategies.

For the first one, students registered information related to time, location, and activity, providing deeper insights into how students engage while studying, materials that are used (e.g., textbooks, websites, and notes).

For the second strategy, a set of problems related to the subject was organised and made available through a web service resource, where the students were expected to post their solutions of the exercises so feedback could be provided, assessing their problem-solving skills based on the use of self-regulated learning strategies such as goal setting, self-evaluation self-monitoring, self-instruction, and self-reinforcement.

Concept maps as the third strategy are usually seen as snapshots of students' knowledge, where the meaningful representation of the relationship between concepts could be drawn; with these concept maps, researchers could acquire a significant representation of the integration of factual, procedural, and conceptual terms of the students' knowledge structures.

Students attended individual interview sessions that were used to train and assess them on the study outcomes. Four learning units of the subject were used for the study, which had been previously identified as key to it. Sessions usually lasted around two hours, which started with the training for the creation of an effective concept map, providing instructions on the components (e.g., nodes, linking arrows, linking phrases), and how they should be created, given them the chance of

completing a practice map; subsequently, students were allowed the creation of one concept map that was related to the topic.

Once the concept was completed, students were asked to work in a set of problems, giving them three minutes for the completion of each problem so they could be carried out during the session; however, the completion of problems during their own time took longer than the three-minute limit. The final part of the session was centred on how to suitably fill out the study strategy diary, guiding them through the process. The process was repeated across learning units 2 – 4, lasting around one hour. Furthermore, problem sets and concept maps were not taken into consideration for the students' course grade; those who had participated were compensated with a voucher.

The information that was registered in the study diaries was coded using 14 self-regulated learning strategies that have been compiled by Zimmerman and Martinez-Pons (1986); problem sets were given a direct score, one point when correct or zero points when incorrect. Concept maps were scored based on proposition accuracy, where propositions are meant to be the smallest unit of meaning in concept maps used to evaluate the connection between two terms (Ruiz-Primo & Shavelson, 1996).

One of the main findings of the study was that organising and transforming, reviewing previous problems, reviewing previous notes, and reviewing texts are the most common strategies used and applied by the students. Moreover, there was a lack of strategies such as seeking information or assistance from peers or lecturers; hence, showing how complex is to cause a shift towards the incorporation of new and more effective strategies, which seems to be a tough task.

As a consequence, the lack of effective strategies shows how certain habits are strongly attached to students' strategic task approach, and the incorporation of new strategies is not as easy as it could have been thought.

Besides, metacognitive strategies such as judging one's own understanding, goal setting, and planning were barely used. Additionally, it was found that students prefer to study alone, except for very few, which could be seen as a lost opportunity, given the positive benefits that those strategies could have on learning and academic success, as the exchange of ideas and questions could nurture and challenge the learning process (Treisman, 1992; Azevedo, 2005).

Also, as an outcome of Lopez *et al.*'s (2013) study, the creation of learning environments that foster students participation in a variety of self-regulated learning strategies is imperative; thus, they could develop a set of approaches, leading to the improvement of conceptual and academic performance. In addition, the need for promoting work group is essential for peer learning development and metacognition during problem solving (Hoekstra, 2008).

Wallin and Adawi (2018) have researched the effectiveness of using reflective diaries as a plausible method for the formative assessment of self-regulated learning in a group of master's students, who were attending a five-month engineering subject at a Swedish university.

The main pedagogy that has been used for delivering this course is inquiry-based learning, which is rooted in the concept that teaching, instead of accentuating the memorization of information, should train students on how to think and act scientifically (Lazonder & Harmsen, 2016). The course has a solid orientation towards formative assessment, looking to foster students' knowledge and skills along the classes, incorporating the ability to engage in constructive self-regulated learning.

As an essential part of the activities of the course, a research project has been included, using it as the main framework for the students to be introduced to reflective diaries. Consequently, students were introduced to the purpose of the diaries and the benefits they could offer to their learning process and project activities. Also, it is relevant to mention that from the 4-member groups that have been organised for the project activity, only one group of the class has been introduced to the reflective diaries' activities.

Therefore, students of that group were requested to write weekly their diaries around a group of significant prompts, which were allocated in four categories of questions: (1) what has happened; (2) how did you approach the situation, (3) why is it important, and (4) what did you learn from it. Additionally, no marks were given for the diaries activity.

Furthermore, for the analysis of the diaries, three key aspects of self-regulated learning for conducting the theoretical thematic analysis as described by Braun and Clarke (2006) were used: conceptions of knowledge, conception of learning, and strategies for monitoring and regulating learning.

From the excerpts that were analysed, it could be said that diaries could be an effective mean to know and understand the knowledge that the students might have regarding the subject, which in turn, could play a significant role in the knowledge process construction, where students are thought to find their own answers, instead of the exact one. Moreover, diaries have helped lecturers investigate the types of learning conceptions students have and support the development of an appropriate learning perspective.

Additionally, diaries have enabled lecturers to identify the self-regulation strategies students apply, which might be difficult to observe in a typical classroom setting. This provides insights that can help tailor feedback to enhance the overall student experience.

Finally, an area for further investigation is whether the study's outcomes can be replicated in a different engineering subject using the same methodology and reflective diaries. It would be valuable to explore whether writing reflections based on specific categories and guided by prompts produces similar results, or if there are inherent elements that might limit their application.

Fryer and Vermunt (2018) have carried out a study in first-year undergraduate students' groups in seven departments of a Japanese university, examining how current methods used for learning strategies could be improved to facilitate the acquisition and retrieval of new knowledge. In their study, they have focused on two aspects of the students' learning strategies, the ways students manage or organise their learning behaviours and the different processes that take place when new knowledge is acquired.

During the first and last weeks of classes, different surveys related to regulation of learning were conducted, with a focus on the longitudinal pairing of regulation (surface approaches to learning, self, external, and lack of regulation). These surveys where clustered in four groups, low quality, low quantity, average and high quantity, which have been the main elements to compare students' responses and see how the students' performance had changed across the academic year.

One of the most important conclusions from this study is the fact that although students apply a moderate number of strategies to self-regulate and reach deep approaches of learning, it seems that these are not enough to move from one group

to another (e.g., from an average performer group to a high quality one), which could be linked to the learning environment not being adequately supportive of the learning process (Baeten, *et al*., 2013).

Also, groups that have been clustered as low performers did not show an improvement in the self-regulation strategies, suggesting that when certain types of students are left to their own devices, it is going to be very questionable that there is an expected enhancement in their performance (Vermetten, *et al*., 1999).

In addition, there was an element that might be worth further exploration, how appropriate the teaching-learning environment is in supporting the student learner development, pointing to an element that has not only been noticed in that institution but in other international ones as well, where the alignment of learning practices is not a reflection of the expected outcomes in higher education (Baeten, *et al*., 2013).

2.4.2 Zimmerman's model

Keeping to the previous concepts, one of the first and principal self-regulated cyclical models was developed by Zimmerman (1995; 2008). In his studies, Zimmerman has studied, explained, and researched the different strategies being used and that influence the self-regulated learning process.

As a result, Zimmerman has identified and proposed the occurrence of three main phases, represented in figure 2.3, that are usually displayed while students are attempting to solve a problem or an assignment, and that ultimately will help learners be focused on the actual tasks and as a result enhance their performance (Zimmerman, 1998).

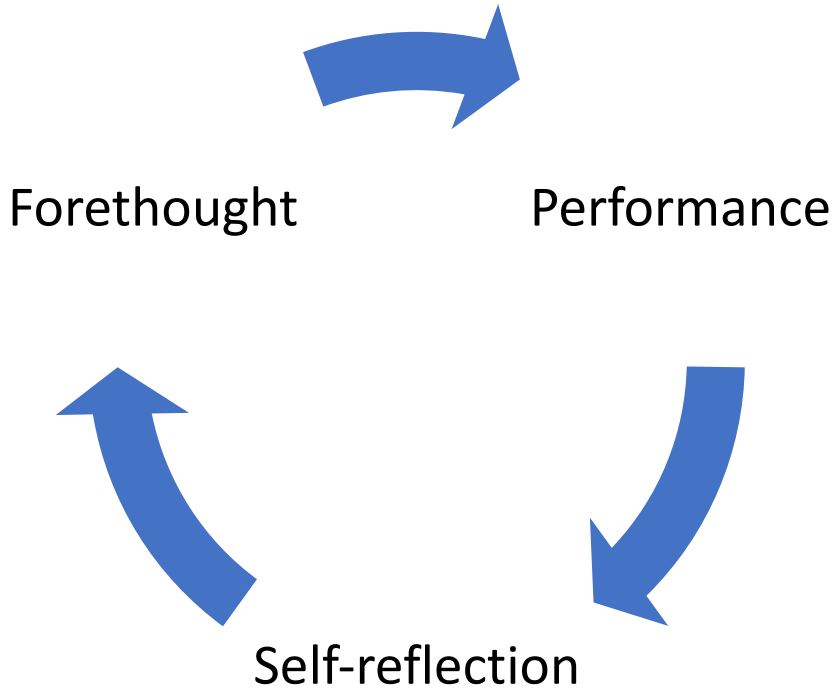


Figure 2.3. Zimmerman's model – Adapted from Zimmerman (1998)

The first stage in Zimmerman's (1998) model is known as the forethought phase, which is the moment when the student faces the task at first, analyses it, sets goals, and establishes a plan on how to reach the goals.

Once the forethought stage is completed, the performance phase is started. In the performance phase, learners attempt to carry out the task while monitoring their progress, using a series of self-control strategies to maintain themselves completely involved and determined to finish the task.

The last stage of the model has been called the self-reflection phase, where learners evaluate how their performance was, making a clear judgement of their failures or accomplishments. This stage has a significant importance and relevance to the cycle, for both, the conclusion of the current sequence as the impact that has caused to the learner's experience and learning efforts, and a direct influence on the forethought phase as the starting point of an upcoming cycle (Zimmerman, 1998).

Zimmerman's (1998) model has served as paramount for different studies in the self-regulation field; also, his model has proved to be one that has conveyed and explained neatly the phenomena that students can experience when dealing with a task or activity, and that not necessarily occur one after another. A factor that shows its

relevance and importance as it has served as paramount for some of the most relevant studies in the self-regulation field. In the following paragraphs, some studies that have used Zimmerman's (1998) model will be explored, showing some practical implications and the evidence that have been grasped.

2.4.2.1 Studies in the self-regulation field

Wigfield *et al.* (2008) have explored children's valuing of task achievement and how they regulate their behaviour in such situations. *Per se*, the reflection stage could be seen as the one posing a significant relevance depending on whether the students see the experience as positive, encouraging them to approach the coming tasks, maybe enthusiastically; or on the contrary, causing a negative experience, where usually the frustration of not getting the expected results might impact the task completion and the start of a new one being directly impacted.

Another factor that has been the focus of Wigfield *et al.'*s (2008) study, is how the student age impacts the task engagement and completion, which is going to have a direct effect over how the relation values and self-regulatory processes change and evolve over time (Wigfield, *et al*., 2008). This has been seen in cases, where first-time students attempt to complete a task, their behaviour has been weak, and as they mature and experience more activities, their attitude and performance get stronger and solid, ideally (Fredricks & Eccles, 2002); aspect that has been identified to be essential, as the demands and complexity of the assignments or tasks tend to be more complex, as the academic year progresses and the complexity of the activities tends to increase.

Moreover, the valuing of activities engagement tends to decrease over time, where it could be the case that children coming to school are excited about learning, interested in new topics, and finding passion for some subjects; however, as students spend more time in school, they start to see the setting as a workplace, causing a decline in the interest towards some activities, resulting in a shift directed to tasks and activities they might find more attractive to them (Jacobs, *et al*., 2002).

Furthermore, activity engagement could be jeopardised, particularly in those students who do not see value in what they are doing; hence, the application of any self-regulatory strategy that might lead to learning is neglected (Brophy, 2010). Additionally, it has been pointed out that for the development of children's motivation

and self-regulation, there is a recurring need for implementing instructional programs that stimulate both aspects, as these might be linked to high levels of achievement, impacting positively the student's progress and academic experience (Wigfield, *et al*., 2008).

Taking Zimmerman's (1998) theories as the main reference, Toering *et al.* (2012) have developed an instrument called the Self-Regulation for Learning Self-Report Scale (SRL-SRS). This instrument has been created with the purpose of measuring self-regulation of learning as a disposition, looking for the identification of strengths and weaknesses related to the learning process. For examining the reliability and validity of the instrument, it has been applied to a group of adolescent students from secondary schools from prevocational and pre-university academic levels in the Netherlands.

The SRL-SRS has been built based on the self-regulated learning strategies proposed by Zimmerman (1998), and from there, taking into consideration six performance aspects, planning, self-monitoring, evaluation, reflection, effort, and self-efficacy, which are at the centre of the self-regulated learning (Zimmerman & Martinez-Pons, 1988). Under the six aspects, fifty questions related to self-regulated learning were allocated.

Initially, a confirmatory factor analysis was carried out to define that the six performance factors were the appropriate ones for the observed data; hence, the participants were divided into two groups, both being administered the test. Later, a test-retest reliability was applied to a randomly selected group, applying twice the test, with an interval of four to six weeks between the first and the second test, looking to avoid that the participants were able to remember the answers given when completing it the first time (Kawabata, *et al*., 2008). The completion of the questionnaire took around 30 minutes.

Once the information was gathered and later analysed, it has been concluded that the SRL-SRS instrument is reliable as a means to measure self-regulation of learning, assuming it as a stable characteristic. However, the instrument might need to be correlated to self-regulation with other factors such as behavioural and see if actual learning of specific subjects is effective rather than a hypothesis. Also, the instrument needs an evaluation that could establish a link between the score that a student gets

and the actual learning that is happening, seeking for a clear indicator that could predict a tangible knowledge progress.

It is important to mention and make clear that the self-regulation strategies, as proposed by Zimmerman (2000) might vary when they are applied by individuals within a group, or even when taking place in a group context, due to the limitations that might arise, such as specific knowledge about the topic that is being discussed, poor preparation for tackling the assignment, and even, lack of fundamental concepts related to the subject (DiDonato, 2013). Also, constraints that students can face when working with others, such as being timid so face fear of asking for peer's help, and emotional behavioural difficulties, can play an important role (Graham, *et al*., 2018).

Kempler and Linnebrink-Garcia (2007) have conducted a study where two small groups (4 team members each) of 6th grade mathematics students at an American school were observed. The observation process took place for 3 days (45 minutes each day), where the students had been working on three tasks (plot some graphs, interpret data, and calculate some base statistics) related to a mathematics unit.

The study has suggested that although both groups have made significant efforts towards regulating their learning and engagement process, the type of regulation strategies that were applied by the groups varied, indicating that self-regulation could happen, but it is influenced by the group context; hence, the context of the group holds a significant impact on the activation of certain strategies.

Behavioural regulation was one of the strategies that have been noticed the most during the group meetings; this happened as an attempt to maintain the group engagement, keeping in mind the time limitation and the deadline for the completion of the tasks. Also, there was a case where one of the students was getting disengaged with what he had been commissioned and another team member noticed it, offering some sort of support. Furthermore, there was a sense of team cohesion and membership as a result of the strategies implemented (Cohen, 1994).

Cognitive regulation strategies such as planning and monitoring were identified during the study, noting that the patterns displayed by the students along the meetings were like those that have been reported in the literature (Erkens, *et al*., 2006).

For planning, it was seen how the students work together at the beginning of the activities to understand and explain the task directions. A noteworthy element that

was observed in both groups was the demonstration of a more forward-thinking planning; for example, this was the case when discussing what type of graph was the ideal one to represent a set of data, which has been described by Santangelo *et al.*, (2016) as part of their self-regulation and writing instruction research, where they have studied more than 1200 students from grades 2-10, encouraging the students to engage in planning activities such as generating, gathering, and organizing their writing content, reporting positive effects as a result of the interventions (Harris, *et al*., 2009).

When looking at monitoring, this has involved the collaboration of all team members rather than a specific team member taking the responsibility. It was also reported that one of the groups realised that one of the plots that was required, had been wrongly drawn, which triggered a series of actions among the group member to tackle the issue, being this a distinctive feature of the monitoring strategy.

Additionally, it was seen how both groups were working together, checking that the calculations that had been executed were correct. Moreover, less effective monitoring efforts such as superficial checks of peer's work, without either extra explanations of what was wrong or providing feedback occurred; and even, it was informed undesirable attitudes of some members towards others. Despite the significant relevance of the study, there is an element that might limit the applicability of the findings, the number of groups that has been observed, where it is not clear if what has been seen in these two groups could be replicated in a similar context with more groups, where the regulatory phenomena among team members have led to a high engagement and consistent learning, and what are the direct connections to off-task behaviours when regulatory instances were activated by the participants.

2.4.3 The autonomy in the classroom

Stefanou *et al.* (2004) have researched the use and promotion of autonomy educational mechanisms in teaching environments, and what their impact, whether positive or negative, could be over students' performance.

Deci *et al*. (1981) have reported that students show higher levels of intrinsic motivation when they have been exposed to autonomy-oriented teaching environments, where autonomy has been supported and stimulated; thus, increasing competence and mastery of motivation among students. And the opposite has been informed, a less-

intrinsic motivation case has been seen in classrooms where students have worked under a more control-oriented style (Ryan & Deci, 2000).

Autonomy support can be recognised based on offering choice, offering explanations of relevance, and offering the students the opportunity to express their concerns and critics about the learning task, fostering independent thinking (Assor, *et al*., 2002).

Based on these elements, Stefanou *et al*. (2004) have deepened their studies, looking into three distinctive strategies – organizational, procedural, and cognitive, that have been associated with distinctive characteristics of autonomy support, aiming to explain the relationship and impact that these factors might have on students' autonomy.

The first one, organizational autonomy, is understood as the encouragement of the student ownership of the environment, this could also include teachers' attitudes that offer students the option of choosing and agreeing certain processes such as group norms, amount of progress that should be achieved towards a goal around a date.

The next one, procedural autonomy support, has been described as the way students could use to present their ideas and concepts, for example, through the creation of pictures and graphs to explain a concept, fostering student ownership of forms.

And the last group, cognitive autonomy support, looks to encourage student's ownership of their learning, where the teacher could be asking questions that challenge students' point of views, requesting them to generate their own procedures to find a solution to a problem, evaluate their own results, or even the ones of their peers (Logan, *et al*., 1995).

As such, Stefanou *et al.* (2004) have taken as an example and as the starting point of their proposition, the research executed by Turner, *et al*. (1998), who observed for about 8 months, 42 students who had been randomly selected from seven groups of the sixth and seventh grades of three American elementary schools, investigating the students' involvement and teaching instructional practices.

Thus, groups were audio and video taped while attending mathematics lessons. The audio-tape lessons were later transcribed verbatim, with the sole purpose of capturing all the instructions given by the teachers and their particular teaching style. In addition, groups have been classified as high-ability, average-ability, low-ability, and heterogeneous.

In this study, it was seen that teaching practices that were thought to foster higher levels of autonomy do not always generate that behaviour in students, but may produce the opposite, where students showed lower levels of engagement. Also, there was the case in some lessons that seemed to be lower in autonomy support, with small room for negotiation (e.g., time for the completion of a task), where students developed a higher engagement and self-motivation towards the generation of ideas, aspect that could have been expected to happen in a more autonomous class setting.

Organizational instances were easily identified, especially in those groups that were centred on autonomy support (e.g., teachers letting students choose group members, agreeing with them on deadlines for assignments, seating arrangements, and providing materials), such processes could have a positive impact on the students by making them believe they can have some control over their activities.

Also, procedural autonomy support instances were identified, where choosing what material was used in the class projects, presentation style of a product, or the design of their own formats. A particular case happened when looking at cognitive autonomy support strategies, as these were strongly linked to what it was said by the teachers in the form of statements, having enough influence for the creation and promotion of cognitive autonomy conditions; this was the case when the teacher asked the students to give a reason for their strategies choice, explain their approach to a problem or solution, the application of different methods to solve a problem.

Furthermore, it has been found that organizational and procedural autonomous strategies tend to support the process of becoming an independent learner to a lesser extent than cognitive strategies, that may take students to a self-motivated and unlimited participation in learning (Brophy, 1998). Despite these, whether or not independent learning lasts in the longer term depends on the learners being engaged in deep learning and being highly motivated (Roeser, *et al*., 1996; Middleton & Midgley, 2002).

Additionally, Veenman, *et al.* (2005) have reported a case study where a group of 41 secondary students in the age of 12-13 years were asked to solve a series of mathematical word problems without the support of a teacher and another series of problems with metacognitive promptings. After analysing how the students reacted to both settings, it was concluded that when students were given cues, there was a predisposition to set goals, select relevant data, establish problem-solving steps, monitor progress, check results, and even, draw conclusions related to the problems.

Likewise, it was noticed how students' performance was better when hints were provided, posing strong metacognitive skills and mathematical performance, even after the corrections for both sets of problems were shared with the group to adjust the learning curve, than when the opposite case, non-cued series, happened (Veenman, 2011).

As such, it could be understood that basic guidelines and indications have a significant relevance for the students' engagement and play an important role, no matter the level of awareness and knowledge that students might have, certain indications could make a significant difference in positively impacting learning progress and enhancing students' consolidation of metacognitive and strategic skills when tackling assignments.

2.4.4 COPES model

The idea that a self-regulated learning model conception takes as the starting point the hypothesis that students use agency by monitoring and adjusting their learning, has been used by Winne and Hadwin (1998) to propose a model to study how students deal with a task.

The model has been called COPES, which is an acronym for conditions, operations, products, evaluations, and standards (Winne & Hadwin, 1998). COPES describes and takes as its baseline four sequenced stages of recursive cognition that Nelson and Narens (1994), Butler and Winne (1995), and Winne (1995; 1996; 1997) have studied, developed, and conceptualised in their research.

Therefore, COPES model hypothesises that a complete model of studying unfolds over four essential and flexible stages (Winne & Hadwin, 2008): (1) task definition, where the student first makes an idea of what the task is and what it entails; (2) goal setting and planning, where the student is expected to define an objective and create a way to achieve it; (3) enactment, when the plan that was previously defined is put into practice; and (4) adaptation, as the activity unfolds, the student adjust the tactics and cognitive structure that are going to impact the upcoming tasks (Winne & Hadwin, 2008).

As a result, in COPES model, each stage of the model of studying could be explained using five facets (Winne & Hadwin, 1998). Figure 2.4 represents how the facets occur and that have been used to elucidate the 4-stage complete model of studying.

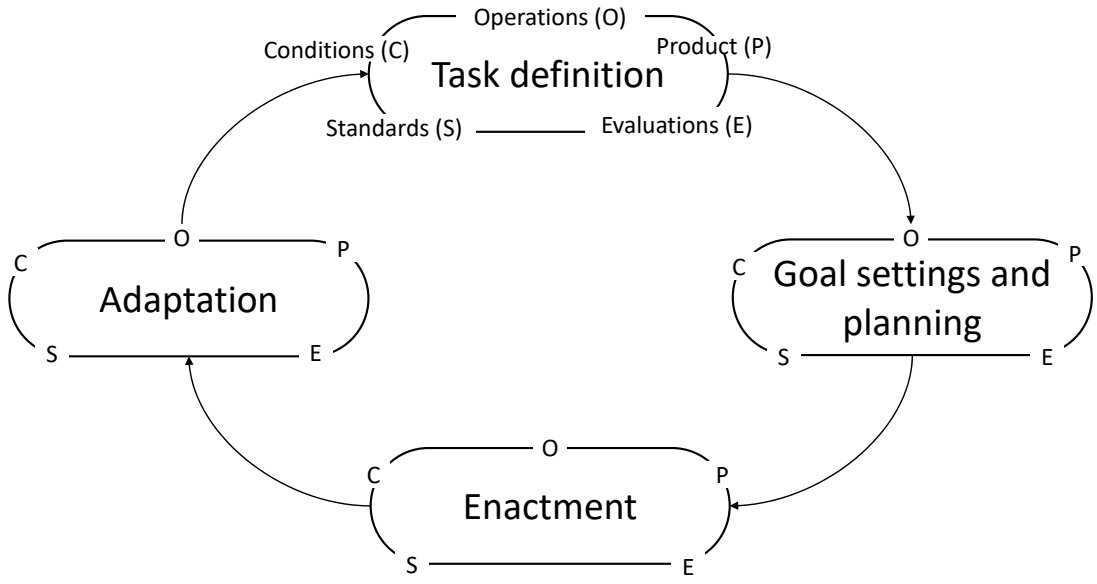


Figure 2.4. COPES model – Adapted from Winne and Hadwin (1998)

The first facet of COPES model is *Conditions*, being defined as those circumstances that have an impact on how the task will be addressed, which includes conditional knowledge, for example, interests, learning styles, time constraints, could be some of those aspects that are related and might influence the task definition stage.

The following one is *Operations*, which are the cognitive processes, tactics, and strategies that a student uses to tackle a task (i.e., searching, monitoring, assembling, rehearsing).

The next facet is *Product,* outlined as the information that is created during the operations facet, which could include opinions such as what the task is, plans for coordinating study tactics, evidence of them – notes, answer to questions, concept maps, and even, updates to standards for judging tactics of study as a way of adaptation.

The subsequent one is *Evaluations*, described as the feedback about products that could be either generated by the student or provided by an external source, which could include judgements about the task during the task definition stage, judgement about an incentive to achieving a goal, how easy or complex a plan might be, the efficacy of putting into practice a plan.

The last facet of the model is *Standards*, which are a set of criteria that are used to check the products, for example, grading criteria for the task, motivation orientation during the goals and planning (Winne, 2018).

As such, COPES model offers a framework for teamwork analysis, stressing out that the decisions and results for each phase of the process are linked with the different dynamics – internal, social, and environmental circumstances – acting as affordances and restrictions for regulation (Hadwin, *et al*., 2018).

Additionally, COPES model has served as the bottom line for the work that has been done by Hadwin, Järvelä and Miller (2011), where they have deepen the analyses of the phenomena that are linked to self-regulation in the context of team group, and how self-regulation evolves along the stages that students face while undertaking a task that needs the participation of the different team members, under the affordances and limitations associated to the learning process itself. Work that is introduced in the following section.

2.4.5 Hadwin, Järvelä, and Miller – Self-regulation in the context of groups

Hadwin, Järvelä and Miller (2011) have worked together investigating self-regulated learning, focussing their attention on groups, and how team members cooperate efficiently to accomplish group work, establishing a collective setting, conveying and allocating tasks, and formulating strategies, incorporating the COPES model (Winne & Hadwin, 1998) into their proposal.

As a result, Hadwin *et al.* (2018) have developed a model that proposed the existence of three modes of regulation of learning in a group working environment: self-regulation (SRL), co-regulation (CoRL), and shared regulation (SSRL) (Järvelä & Hadwin, 2013) (see figure 2.5).

These three modes of regulation could occur depending on the circumstances, context, and social interaction that might be happening among individuals while attempting to complete a task.

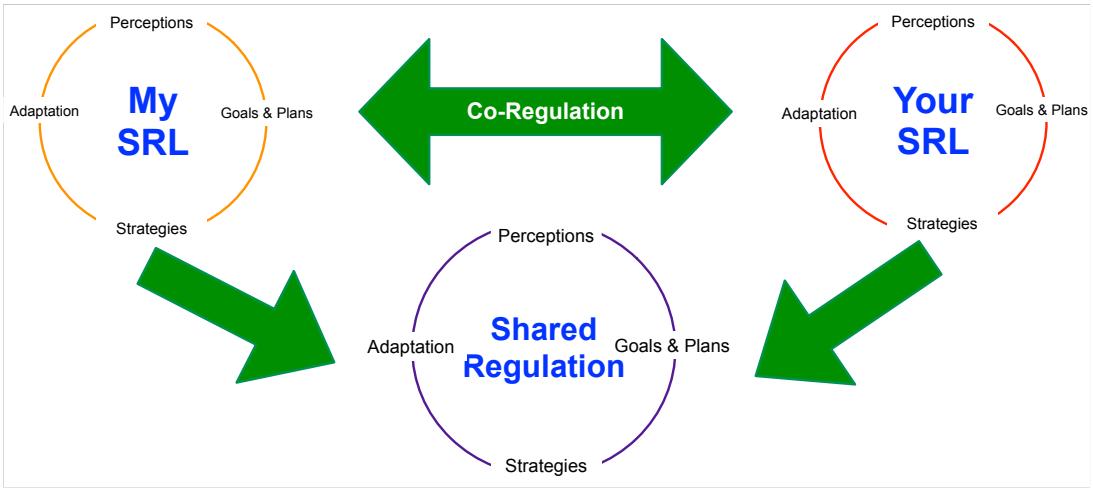


Figure 2.5. Regulation in a group working environment – Adapted from Hadwin *et al.* (2018)

These modes of regulation are defined as follows (Hadwin, *et al*., 2011; 2018):

Self-regulation of learning (SRL) in a collaborative setting refers to the individual's action within the group that is connected to the way adaptation is performed while interacting with other team members (Hadwin, *et al*., 2011). Self-regulation of learning encompasses the individual responsibility of one's cognition, behaviour, motivation, and emotions as required (Zimmerman & Moylan, 2009).

Furthermore, SRL is genuinely metacognitive, knowing and evaluating his/her adaptation; agentic, owning the definition of his/her own goals and perception – *"I" perspective* (my task perceptions, my goals, and plans), and also, it serves as the framework for his/her monitoring and evaluation (my adaptation, my task strategies) (Järvelä & Hadwin, 2013).

In addition, self-regulation of learning is socio-historically and contextually situated, being formed by personal and group experiences and beliefs, and shaped by the situation and the shared task commitment (Järvelä & Hadwin, 2013). Also, it has been apparent that self-regulated learning during teamwork is corresponding to the occurrence of shared regulation instead of being divergent (Hadwin, *et al*., 2018).

Co-regulation (CoRL) is defined as the affordances and restrictions that motivate the students' allocation of planned activities, performance, deliberation, and adjustment (your adaptation), that usually occur when there is interaction with other learners or members of the group – "*you" perspective* (your task perceptions) (Järvelä & Hadwin, 2013), so temporary help may appear when any of the team members needs support

to solve his/her assigned task (Hadwin & Oshige, 2011). In doing so, a momentary and fluctuating support among team members takes place, where there is an awareness of each other's goals, beliefs, and progress development (your goals and plans), as another peer is shaping them (your task strategies). Also, CoRL could happen when cognition, motivation, emotions, or behaviours are momentarily conveyed or emerged as necessary (Hadwin, *et al*., 2018).

Finally, *Socially Shared Regulation* (SSRL) is the manner in which diverse perceptions, adaptations, tasks, goals, and plans are taken across the whole group (Järvelä, *et al*., 2008). SSRL is transactive, where there is a contribution of different individual perceptions that converge metacognitive, cognitive, behavioural, and emotional.

SSRL is strongly metacognitive, as such, monitoring and evaluation are shared among the members of the group – *"we" perspective* (Järvelä & Hadwin, 2013); mutually agentic, hence, common goals and criteria (our task perception, our goals and plans, our task strategies, our adaptation) are intentionally agreed so as to measure and evaluate team progress; and it is socially and contextually situated, then is shaped by individual and communal beliefs and experiences, creating a set of shared conditions that are continually adapted as there is a joint engagement around the task or assignment (Järvelä, *et al*., 2013). Additionally, there is an important distinction that might be worth making at this point, co-regulation involves two members of the group regulating the task together, whereas social-shared regulation involves the whole group as an entity (Järvelä, *et al*., 2016).

What is more, one advantage that could be claimed for Hadwin *et al.*'s (2018) model, it that among the self-regulated learning models, this model provides a more specific and detailed explanation of the different stages and processes that could happen in a group setting (Greene & Azevedo, 2007). However, this model has been applied to the whole self-regulated learning process at a general level and has used the COPES model facets without making a clear distinction among neither the COPES model facets, nor the complete-model-of-studying four stages – task definition, goal setting and planning, enactment, and adaptation (Schoor, *et al*., 2015).

Consequently, Hadwin *et al.*'s (2018) model application to granular interactions such as discussing the task, reaching an agreement, creating a strategy, that normally

happen in a group context are more difficult to analyse at a granular level, and even more, when trying to make a distinction of the transactional stages that could occur while shared-regulation of learning is happening.

Table 2.1 is a compilation that offers the definitions for each stage within the SSLR, which have been adapted and used by Miller and Hadwin (2015) in the context of team work, and that has been based on the research carried out by Butler and Winne (1995), which have served as their studies bottom-line and framework.

Furthermore, tables 2.2 and 2.3 present some examples that have been provided by Järvelä *et al.* (2016), which are related to the phases – task perception, goals and plans, task strategy, and adaptation – within the SSLR, illustrating the definitions in a real learning context, showing utterances of the interactions of 4 groups of students, who have been undertaking some tasks and have had some sort of interactions while accomplishing their work, indicating how the SSLR phases are displayed and identified while different transactions, exchanges, and forms of collaborations happen within teams.

The subsequent section presents an extension and continuation to the work undertaken by Järvelä *et al*. (2016), that has been expanded by Schoor *et al.* (2015), proposing a broaden model that aims to explain the transactions that occur under the COPES model, the stages for the completion of a task, and the shared-regulation of learning in the context of teamwork.

Table 2.1. Socially shared regulation in context – Adapted from Miller and Hadwin *(2015)*

Socially-shared regulation	
Task perception	Aligning individual task perceptions, beliefs and self-knowledge to negotiate shared: (a)perceptions of task requirements, purpose, and social context, and (b)awareness of our collective strengths, weaknesses, and task responsibilities
Goals and plans	Aligning personal goals and standards to negotiating consensus around joint goals, standards, and plans to guide our collective task completion
Task strategy	Negotiating and co-constructing strategies and approaches to attain shared-task goals and standards, maintain motivational engagement, and mediate socio-emotional challenges
Adaptation	Collectively driving or making changes to joint task perceptions, goals, and plans when needed for the current task or future tasks; collectively persisting and finding solutions in the face of a challenge

Table 2.2. Examples of socially shared regulation in context – Adapted from Järvelä *et al. (2016)*

Task perception	**Maria:**	What is our agenda today?
	Jani:	We should brainstorm ideas for constructing our case story.
	Maria:	Oh, that's right.
	Jani:	(reads the task instructions aloud)
	Maria:	... so case description and analysis is needed.
	Jani:	I am wondering why the task deals with motivational problems, not self-regulation?
	Pia:	I think that motivation is part of self-regulation, or is it so...?
	Jani:	Yes, but it is easy to find motivation problem cases without self- regulation.
	Maria:	Hmm ... doesn't self-regulation actually help to handle motivational problems?
	Jani:	It depends on the problem, but let's integrate these aspects in our case description.
Goals and plans	**Anna:**	How should we progress to create a coherent answer for the task?
	Matti:	Could any one of us start by integrating the ideas?
	Mari:	Yes, why not first copy/ paste all ideas to the word document?
	Anna:	I can do that and write a summary. I like summarizing things.
	Mari:	OK, so you can include volition and feedback and add something about self-efficacy.
	Anna:	That's right. I'll summarize what we have now and send it for your additions by e-mail.
	Mari:	Very good!
	Matti:	I agree!

Table 2.3. Examples of socially shared regulation in context – Adapted from Järvelä *et al. (2016)* (cont.)

Task strategy	**Jussi:**	Minna has an excellent definition about metacognition, why don't we use it, mine is much more superficial.
	Pauli:	I can add a few aspects.
	Minna:	Yes, please, Pauli could add a few, such as a more specific definition of cognition.
	Pauli:	I can think about integrating Minna's and my own thinking.
	Minna:	Yes, let's conclude so that will add Pauli's most Important issues to the final definition. That will be an excellent answer to the task.
Adaptation	**Manda:**	What's our plan for this assignment? Last time [assignment 1], we split it up. Are we doing that again?
	Riley:	We all contributed really well last time but each did very individual work. We need to do a more effective job of working together this time.
	Mari:	Yes, why not first copy/ paste all ideas to the word document?
	Shay:	We didn't really change anyone's parts. I think since we didn't read what people did, we missed out on a chance to pool our knowledge and do better.
	Manda:	Okay, so let's make sure we give feedback on each other's answers in order to use all our knowledge in solving the problem.

2.5 Coding Scheme for the analysis of Socially Regulated Learning (CASoRL)

Schoor *et al.* (2015) have carried out a revision of the terms and concepts that have been used for the description of regulation of learning and that are directly related to cooperative and collaborative learning, making a specific emphasis on the regulation that occurs during the group process.

In the teamwork context, it has been said that socially shared regulation is associated to the specific circumstances of the learning stage (Greeno, 2006), which is not the same case for co-regulation, where the social environment (i.e., the team) is used to assist an individual with regulation (Järvelä & Hadwin, 2013). In addition, in socially shared regulation of group processes, the focus of attention is on the group as an entity, and not on any specific team member (Reimann & Bannert, 2018), which is the specific case of my research.

From Schoor *et al.'s* (2015) revision, a special interest has emerged in the COPES model (Winne & Hadwin, 1998), which has been fundamental for the conception of the three modes of regulation of learning in the context of collaboration – self-regulation, co-regulation, and shared regulation, and that have been presented by Järvelä and Hadwin (2013).

In their analyses, Schoor *et al.* (2015) have delved into the COPES model, through the categorisation of its facets – conditions, operations, products, evaluation, and standards, applying it across different forms of regulations such as self-regulation of learning, socially shared regulation, socially shared metacognition, among others, which have been found in the literature and that are associated to cooperative and collaborative learning.

The previously mentioned forms of regulation have been identified following a regulatory loop model, using the '*I*, *you* and *we'* perspectives. Besides, in Järvelä and Hadwin's (2013) work, the application of that regulatory loop seems to have indicated a non-dependency among facets and stages – task perception, goals and plan, tactics and strategies, and adaptation, which ultimately do not reflect on the intricate relationship that might exist in a mode of regulation. In some cases, the product of a task could become the standard for another one, thus, a certain form of association could be established (Schoor, *et al*., 2015).

As a result of this revision, Schoor (2018) has developed a coding scheme with the aim of analysing group discussions from a diverse number of sources (e.g., videos, audios, and chat protocols) in collaborative learning that relates to different forms of social regulation of learning. The coding scheme has been called CASoRL, which stands for Coding Scheme for the Analysis of Social Regulation of Learning.

In order to use the scheme, the data are expected to be segmented into coding units that are suitable for the research question, for example, which modes of social regulation occur according to the environment; once this is executed, the first step to follow is the identification of regulatory utterances, that has been called auxiliary level and that has been developed based on the four stages of a complete model of studying (task definition, goals and plans, enactment, and adaption) (Winne & Hadwin, 1998), proposing a variation into task definition, planning, cognitive task processing, and regulation, and incorporating acceptance, coordination and ‘other’ for a much clearer differentiation of regulation instances.

Table 2.4 expands the definitions and provides examples in context of how the instances might look like (Schoor, 2018).

Table 2.4. CASoRL – Auxiliary level, adapted from Schoor *(2018)*

Coding category	Definition	Example
Auxiliary level – AL: Coding content		
Task definition	Talking about what the task is	"We are supposed to develop an outline in point form"
Planning	Talking about what to do in order to solve the task (general strategic procedure)	"Let's take you handout and add things if necessary" (at the beginning of the cooperation after an individual phase in which an individual handout was produced)
Cognition	Talking about the solution of the task, but also constructing or sharing the knowledge that is necessary for the task	"I think it is important that she shows Leo that he can improve his performance by good hard work, for example via formative assessment"
Regulation	Monitoring, evaluation or controlling of task definition, planning, cognition, or regulation	"I think really enhancing motivation would be points number 2 and 3"
Acceptance	Fast and simple acceptance of statements that were coded task definition, planning, cognition, or regulation	"That's great" "OK"
Coordination	(Technical) Coordination of the learning partners	"I'll write this into the handout, ok?"
Other	Off-task; not codable	"We go home"

In the second step, considered to be the principal level of the scheme, the utterances that have been previously assigned a category of regulation in step one, are now coded based on the social perspective depending if the operations, products, evaluations, and standards (OPES), which have been adapted from the COPES model (Winne & Hadwin, 2008) are shared (*we perspective*), someone else's (*you perspective*), or the speaker's (*I perspective*), resulting in the assignment of a mode of regulation (Schoor, *et al*., 2015).

Schoor (2018) has decided not to consider the conditions facet of COPES model, as it seems not to explain a shared regulated mode but to offer the possibility of switching to a different mode of shared regulation, as explained by Schoor *et al.* (2015).

Table 2.5 offers a much deeper detail for the principal level of the scheme, providing a definition and examples for every single perspective occurring under the OPES structure.

Table 2.5. CASoRL – Principal level, adapted from Schoor *(2018)* (cont.)

Coding category	Definition	Example
Principal level – PL: Perspective of OPES – Operation, Products, Evaluation, Standards **(Winne & Hadwin, 1998)**		
Operation	Actions being taken or supposed to be taken, e.g., writing something into the joint product. Main question: Who does something, is supposed to do something, or has done something?	
We	We have done something / are supposed to do something / do something	"Great, this looks good!" (Referring to the jointly produced solution / what we have done)
You	You have done something / are supposed to do something / do something	"I think you made the task unnecessarily difficult because you wrote so many details"
I	I have done something / am supposed to do something / do something	"This looks very confusing now" (referring to something that he himself has changed in the handout)
Product	The currently strived for results, e.g., the joint task solution but also the solution for an unclear question about the content or things alike. **Main question:** Whose product is being talked about? Their own, another one's, the joint?	
We	It is talked about our joint product	"Great, this looks good!" (Referring to the jointly produced solution / what we have done)

Coding category	Definition	Example
You	It is talked about your product (the product of the other)	"You have written way more than an outline and definitions"
I	It is talked my product (the product of the speaker)	"What do you think about my outline?"
Evaluation	The comparison of actual state and ideal state. **Main questions**: Who evaluates? Who is supposed to evaluate?	
We	The evaluation is done jointly or is supposed to be jointly	"Do we this as the final version?"
You	The other person evaluates or is supposed to evaluate	"What do you think about my outline?"
I	The speaker himself/herself evaluates	"You have written way more than an outline and definitions"
Standard	The goal or the ideal state that is used to be compared with the current state. **Main question:** Whose standard is used or is supposed to be used?	
We	A joint standard is used	"We agreed upon writing in note form, and this is now continuous text"
You	The standard of another group member is used	"What do you think about my outline?"
I	One's own standard is used	"I think you made the task unnecessarily difficult because you wrote so many details"

CASoRL has established two essential criteria for its application, a) regulation always happens with regards to a standard or goal, and b) regulation will always involve higher-level processes such as monitoring, evaluation, or controlling (Schoor, 2018). Also, CASoRL has been designed for any type of group discussion in collaborative learning, being the only scheme that distinguishes more than three modes of social regulation of learning, given that similar models that have been proposed in the socially shared regulation area, such as the work executed by Hurme *et al.* (2009) and Rogat and Adams-Wiggins (2014), have assessed only one or two modes of regulation.

CASoRL's reliability has been verified through a pilot study that took part on a computer-supported collaborative learning, where two researchers coded 14 pairs of interactions, equivalent to 527 tries, reporting a high rate of inter-reliability; because of this pilot study, its validity is presumed (2018); however, the results of this pilot are yet to be published. Finally, as CASoRL has been conceptualised based on theoretical and empirical evidence, more explicit empirical tests are required to demonstrate its relevance and applicability within the educational context.

The following section presents the studies that have been done by Schunk and Ertmer (2000) and Perels *et al.* (2005), with special focus on activities that have been designed to promote self-regulation in the context of teamwork.

2.6 Activities to promote self-regulation of learning

As self-regulation is recognised to have a crucial role in learners' success, educators have tried to come up with ways to promote self-regulation (Breitwieser, *et al*., 2022).

In trying to elucidate how self-regulatory competence could be encouraged through some methodological interventions, Schunk and Ertmer (2000) have proposed four elements to be considered to fostering self-regulatory strategies and self-efficacy for learning, (1) give students a considerable responsibility over their own learning, and not only rely on social models; (2) self-regulation research should be carried out in the context of content area learning, suggesting that when self-regulatory methods are connected to academic content, there is a higher probability that students learn how to apply them in a learning environment; (3) self-regulation processes should be taught and integrated in different subjects; thus, the strategies transfer issue is

avoided and adjusted as needed; (4) self-reflection practice should become a habit so evaluation of students' own progress is performed, allowing them to adjust certain factors that might be causing underperformance.

However, in Schunk and Ertmer's (2000) research, there was an evident need to expand and actually, put into real practice their assertions, specifically, those referring and connected to the teaching of self-regulation processes and self-reflection as a habit, aspects that have been more theoretical oriented presented than practical applied in the context of teaching and learning.

Following these elements and the need to explain how self-regulation could be integrated in the classroom environment, Perels *et al.* (2005) have proposed a model of self-regulated learning that incorporates the self-regulation theories and concepts of problem-solving, and that follows a sequence of learning stages. Three phases make up the model, pre-action, action, and post-action, which are defined as follows:

In the *pre-action phase*, the task is the starting point of the self-regulation process, and it is at this stage where students set their goals (Zimmerman, 1998), which are going to be influenced by their motivation (intrinsic and extrinsic) (Ryan & Deci, 2000) and environment; also, self-efficacy has been included in this phase, as a factor that could have a positive impact on self-regulatory factors such as effort, persistence, and achievement (Schunk & Ertmer, 1999).

The next phase, *action,* is concentrated on the learning strategies (cognitive, metacognitive, and resource management) that could be used by the students (Pintrich & de Groot, 1990).

And the last phase, *post-action*, is focused on self-reflections, distinguishing self-judgements and self-reactions that could emerge once a task is completed (Bandura, 1986; Zimmerman, 2000).

Consequently, Perels *et al.'s* (2005) model has been applied to assess its pertinency and helpfulness in improving students' learning competencies in mathematics, while combining self-regulation and problem-solving strategies. Therefore, 240 students of the 8th grade from three German schools participated in the study.

The training program took place during 6 sessions on a weekly basis during the afternoon, lasting about 90 minutes each. A pre-test was applied at the beginning of

the study, which contained a self-regulation questionnaire and a problem-solving test; then, during week one and four of the study, an analogous problem-solving test and the same self-regulation questionnaire were conducted. The pre-test was used to establish a baseline and allow comparison of students' performance before and after the training.

In the self-regulation questionnaire, the students were given a series of statements about goals, motivation-volition, learning strategies, self-reflection/handling errors, and self-efficacy. Statements such as '*when studying, I copy my notes over to help me remember materia*l' and '*I like what I am learning in this class*' (Pintrich & de Groot, 1990) were included, which should be evaluated by selecting one of the options from a 1- 4 scale (1= I don't agree at all; 2= I don't agree; 3=I agree; 4=I agree completely). For the problem-solving test, 17 problem-solving tasks related to basic mathematics and heuristic strategies such as working forward and backwards, and the principle of invariance, tables, figures, and equations, were included.

Students were assigned to four experimental conditions, (1) self-regulation, (2) combined training (self-regulation and mathematical problem-solving), (3) problem-solving training, (4) no training (control group). For assuring an appropriate deployment of the training, students were assigned to one of the experimental conditions and were divided in groups of no more than 19 students, including the control groups of up to 25 members.

The first day of the training started with a description of the model of the combined training, and then asking the students to use their strategies to solve a mathematical exercise; later, the heuristic strategies were explained and put into practice using a couple of examples. At the end of the session, a general reflection related to problem-solving strategies use and how to regulate the attention was held. Two subgroups answered a series of questions before and after their homework for the duration of the intervention. The learning diary invited the students to observe and reflect upon the session to support the training progress.

For the subsequent days of the training, the other heuristic strategies were taught and so were the self-regulation strategies (i.e., how to set goals, volitional strategies, self-reflection). During the 4th day of the training, a summary about the previous training days was given to the students; additionally, for this day, a special focus was given to motivation, as a crucial element associated to self-regulation. For the last day of the

training, a review of the program and self-reflection and how to handle errors were presented to the students. The day was concluded with the students being taught how to connect all the different strategies that made up the program.

It was found out that after this intense training an effective improvement was noticed in students' performance when applying problem-solving skills. However, this was not the case for the self-regulation component, where results did give indicators of enhancement but not as strong as those related to problem-solving skills. This is a clear indication that these self-regulatory strategies are more difficult to train compared to problem-solving skills. Nevertheless, the combination of both pedagogical strategies appears to be beneficial to the German grammar learners' performance.

2.6.1 Essential knowledge strategies

Svinicki (2004) has researched extensively the necessary metacognitive aspects that a learner needs to put into practice and what learning strategies and tactics could serve him/her so they could be more in control over their learning process, more reflective about, and know what they can derive from it; hence, certain level of knowledge on learning is reached. Therefore, four aspects of knowledge on learning have been included as essential to cognitive aspects:

(1) *knowledge of strategies and tactics* – students need to know what tools are available so they can control their learning progress; thus, when a strategy that has been used is not shedding the expected outcome, they know about the existence of others.

(2) *knowledge about task demands* – tasks are going to have different cognition needs depending on the subject or area that is being studied; hence, students are required to comprehend what strategies are the most suitable to put into practice accordingly.

(3) *knowledge about themselves as learners* – knowing what strengths and preferences one has could play a significant role when learning; some learners might ignore them, missing the chance to make the most of particular strategies that could work for them, while using others that are unfitting for their learning needs, and

(4) *executive process knowledge* – students who know how to monitor their leaning progress, set goals and make plans to achieve them, and admit when they

are stuck and what to do about it, will have a significant advantage when learning, and surely, have already mastered the other three aspects.

As a result, if a learner can control his/her metacognitive processes and effectively use his/her knowledge, directing them towards a goal, the most probable outcome would be a successful completion of the task or activity (Svinicki, 2004). Hence, knowledge is acquired as a form of concepts about a set of related characteristics, objects, symbols, or events that share common elements in context (Schunk, 2011).

2.7 Summary

This chapter has presented as assortment of studies on which this research has been founded. It has provided a set of foundations that have served to identify the gap that this thesis seeks to bridge, providing a justification to further examine students' teamwork. Finally, aiming to make up an addition to the body of knowledge, in particular regarding autonomy and self-regulation processes within groups' interactions.

The next chapter (**3**) will describe in detail what methodology has been used along the research for the analysis of the data corpus, and the method that has been conceptualised for the definition of a scheme to be added to the self-regulation under an educative framework.

3. Research design

This chapter describes how this research has been carried out. It outlines the theoretical framework under which the research has been conceptualised and undertaken. It also presents the methodology of analysis, including the type of qualitative methods that have been explored, evaluated, and used for the data analysis, and the methods of data collection that have been applied throughout this study.

Furthermore, the chapter also describes how the data analysis has taken placed along the development of this research, presenting a detailed description of the transcription and data sessions as essential processes to this study.

3.1 Theoretical framework

For the development of this research, there was the need to identify the underpinning learning theories that were most aligned, and also closer to the shared regulation of learning phenomena, which has been researched in the context of project-based learning, being a central element to this study.

Among the theories that have served to explain how people usually learn and that have influenced educational practices over the years, already introduced across section 2.1, behaviourism, cognitivism, and constructivism are the most relevant to the learning context where this research has been undertaken (Kincheloe, 2005). The latter, constructivism, was the one that has served to frame this study, but specifically, a variation of constructivism, social constructivism that posits that learning is an active, collaborative process where individuals construct knowledge through social interaction and engagement with their environment (Oldfather, *et al*., 1999).

Consequently, the principles of social constructivism stress that individuals actively construct knowledge and understanding through social interaction, discourse, and engagement with their environment (Detel, 2001). Hence, social constructivism highlights the dynamic and reciprocal nature of learning, where individuals co-

construct meaning through dialogue, collaboration, and negotiation of ideas (Kalantzis & Cope, 2012).

Furthermore, social constructivism emphasizes the role of learners as active agents in their own learning process, advocating for student-centred approaches that promote autonomy, critical thinking, and metacognitive awareness (Jackson, 2010). Aspects that have led this research to take a naturalistic and qualitative analytical approach to investigate the occurring phenomena in an authentic learning environment.

3.2 The project assignment context

As introduced in section 2.2, problem-based learning (PBL) is an educational method, where an ill-structured problem is introduced to the learners, triggering the learning process with a loose support (Wijnia, *et al*., 2019); and it is here, where PBL offers a great framework, as there is no unique right answer to the challenge that has been posed, opening the discussion and stimulating a series of interactions among learners, that in the best scenario, would lead to the conception of a feasible solution (Dolmas, *et al*., 2005).

Besides, project-based learning (PjBL) as a variation of PBL, gets a significant relevance in the higher education context due to the fact that students could address a real problem, or one much closer to those faced in a professional environment (Warnock & Mohammadi-Aragh, 2016). In doing so, students are expected to organise their own activities and distribute the working load among themselves, subsequently, a solution is perhaps proposed; lecturers and tutors would act as advisors rather than as formal academics. Duration of the activities to solve the problem could take a significant length, with the delivery of an end product, such as a report, plan, model, etc. (Helle, *et al*., 2006).

Consequently, during the first semester of the CP306 Process design and Simulation module – from September to December, students have been working on the completion of a series of problem-based learning cases, covering aspects related and relevant to a characteristic chemical process design project. The topics are:

- The business case and market for designing a chemical plant
- Preliminary design (Material and energy balances, producing a chemical database, development of a process flow diagram)

- Safety and environmental implications of chemical process design
- Specific equipment design (heat exchanger design, pump design and selection, phase separator design).

These topics will be then the bottom line for the completion of the concept-project for semester 2 – from January to March. The module lecturer has conceived the assignment applying the general structure of the PjBL methodology, around the proposal of a conceptual process design of a plant to produce a chemical product, which is particularly used in the chemical and process industries, agricultural, and mining sectors.

The assignment has been presented to the students in a memo-file style (see **Appendix 1**). The document details every single requirement that is expected to be submitted as part of three main deliverables: technical proposal, basic engineering design report, and the delivery of a presentation to a fictional client board of directors; it also made specific mention of key dates for each activity.

The first deliverable that has been required as part of the assignment is the technical proposal, which has been divided into six elements for the report submission – see figure 3.1 for reference.

Figure 3.1. First deliverable – Technical proposal

These six elements have also included specific information about the process; thus, the decision-making process is expected to be more robust and so enough, and in-depth discussions and analyses could take place along the group meetings.

The second part of the submission is a report that has been framed for the basic engineering design report. As follows, this report has been organised into twelve elements, including but not only exclusive to engineering aspects, environmental, and economic considerations. Figure 3.2 presents the sections that make up the submission.

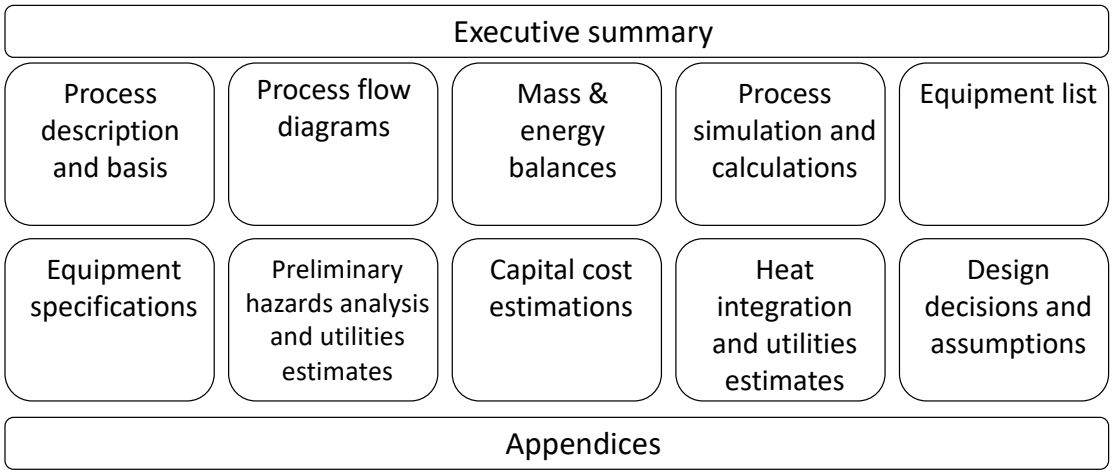


Figure 3.2. Second deliverable – Basic engineering report

The third part of the assignment is a presentation of the basic engineering design to the board of the 'company' that have requested the plant design, showing the development and outcomes of the preliminary conceptual design. This presentation is key for the further progress of the project, given the fact that students will receive direct feedback regarding their progress, and if incorporated, a realignment and redirection of their project activities could take place.

Table 3.3 presents the per cent weights that have been assigned to each activity that has taken place across the academic years. Furthermore, for the second year of data collection (2018 – 2019), the first three components have been removed as they were no longer considered as part of the assessment criteria, giving more relevance to the project report, individual tests, and quizzes. It is important to mention that although during the 2018-2019 academic year a data collection occurred, it has not been used in this research; instead, it used exclusively the 2017-2018 audio- and video-recorded data.

Table 3.1. Assessment detail

Academic year	**Assessment type / Weighting (%)**					
	PBL summary	Reflective portfolios	Group presentation	Project report	Individual test	Simulation quizzes
2017 – 2018	15	5	10	30	30	10
2018 – 2019				45	45	10

Furthermore, during the subject classes, students had access to the subject teaching assistants or class facilitators, where they had the chance to ask for any type of support towards the project-based learning cases and project completion activities. For the latter, there was a constant monitoring of the project tasks that were expected to have been covered each week, keeping a record of how they were dealing with the project assignment, and in the event, any nuisance was identified, this was to be reported to the lecturer for further support and clarification.

Also, the team groups had available a specific on-demand weekly slot with their lecturer during the whole academic year, that could be booked to ask for support concerning the class and project activities, seek technical advice regarding the project proposal, and even, discuss any problem that the teams were facing. Being an important class arrangement to address and tackle issues that could impact the performance of the teams.

Additionally, it is relevant to make a clear statement about what my position was during the audio- and video-recorded project meetings and plenary sessions. The data have been collected during the 2017-2018 academic year, make up the main source of the data corpus that has been used along this research.

The compendium of files has been produced by two members of the SkIL (Skills, Interactions, and Learning) research group; process that took place while I had neither started my research nor had any academic relationship with the Chemical and Process Engineering Department. Besides, I did not have any academic and social interaction with the students, members of both focus groups.

A data collection was done during the 2018-2019 academic year, where I had an active participation; however, this data corpus is raw data, since it was neither explored during the completion of this study nor has been processed. Likewise, the contact with the group of students during the project meetings was kept at minimum, which was almost similar to the interactions that I had with them during module plenaries, avoiding any possible interference with their activities and alterations to their behaviour.

Lastly, the marking of the project assignment submission was done by the module leader, where I had no participation or involvement whatsoever.

3.3 Methodology

One advantage of studying teams is the fact that they are common, not only in academia but also in industry and real life (Einola & Alvesson, 2019). Thus, they create the perfect setting to be able to identify patterns of how students develop shared regulation, via common behaviours that individuals show when dealing with tasks that involve mechanisms of regulation (Saab, 2012) (see figure 3.3).

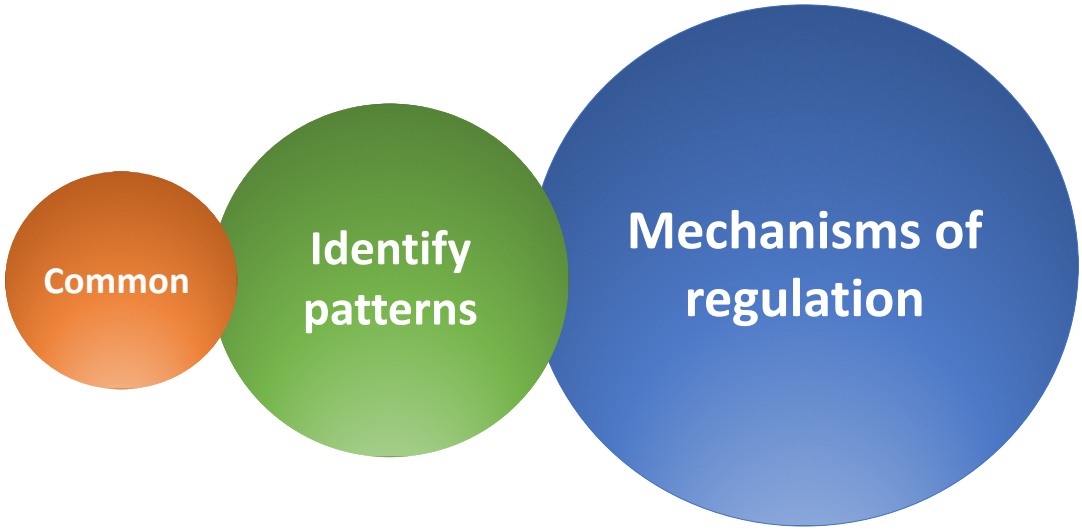


Figure 3.3. Motivations to study teamwork in academia

As previously described in **Chapter 2**, it has been fundamental to comprehend how collaboration, and specifically self-regulation, occur within a group context, and whether or not the associated transactions and interactions lead to the successful completion of the task that has been assigned (Hadwin, *et al*., 2018). Similarly, how the various stages of the cognitive process take place: search of information in the surroundings and memory, definition of goals, tackling the task, and adjusting the strategy to face future goals (Winne & Hadwin, 1998; Winne, 2018).

This research is focused on the investigation of students' behaviours in teams (i.e., team self-regulation strategies, self-evaluation, goal setting and planning), and their performance features (i.e., task perception and completion, strategy knowledge, engagement, and the quality of the final project outcome), when dealing and undertaking project-based learning (PjBL) activities in a chemical and process engineering design course.

Furthermore, a qualitative analysis approach has been selected for the analysis of the data corpus, being more suitable for video and audio research as it allows researchers to capture and analyse the rich, nuanced information that is contained in these types of data. Audio- and video-recording data can reveal a wide range of information about people's experiences, beliefs, and perspectives, including their nonverbal communication, body language, tone of voice, and interactions with others (Macnaghten & Myers, 2013).

Also, qualitative approaches allow researchers to analyse rich data such as audio and video files in a holistic way, taking into consideration different factors that could contribute to meaning (Bryman, 2016). This has been the case, where a researcher has used a qualitative method to study and describe how egocentrism is developed in a group of children while they were in their house. They were video recorded during the afternoons, while interacting among themselves and also with their parents, aiming to structure a typology of practices and statements of the children in different episodes (Flick, 2018).

3.3.1 Qualitative methods

A qualitative method is an approach for researching that commonly uses words as data (Braun & Clarke, 2013), organising, accounting for, and giving a meaning to the data (Cohen, *et al*., 2011). Therefore, this research uses the written speech of the students' interactions as the main data corpus, to later describe these exchanges, making sense of them in a defined and structured way (Schreier, 2012).

Due to the nature of the data that have been collected for this research, three qualitative methods for the data corpus analysis have been considered. These methods are introduced in the subsequent sections.

3.3.1.1 Qualitative Content Analysis

The first method to be explored was Qualitative Content Analysis (QCA). QCA is a method that is used to describe the meaning of qualitative material in a systematic way (Schreier, 2012), and where content and context of the data are analysed (Ritchie & Lewis, 2003).

The method starts with deciding the research question that is going to be explored, followed by the selection of data excerpts, and then, the construction of a coding

frame – involving distinct categories with their subcategories. Later, it divides the data that are of interest to the researcher into units of the coding frame.

Once all these stages are executed, trying out the coding frame through double-coding, where each unit of analysis is coded independently by two or more coders. The coders then compare their coding results and discuss any disagreements. Thus, this process helps ensure that the coding is consistent and valid. All these are essential to see how it fits in the data corpus and evaluate, if some modifications or adjustments are needed (Schreier, 2012).

For ensuring the significance and accuracy of the framework that have resulted from this approach, two elements need to be satisfied, reliability and validity (Hsieh & Shannon, 2005), which are common among qualitative methods.

Reliability is understood as how replicable could be the findings of a research; it is said that due to the human nature of the researchers, coding errors are an inherent element and can only be minimised but not avoided (Silverman, 2011); thus, certain criteria should be met for a model to be reliable: stability, reproducibility, and accuracy. The former is achieved when there is clear tendency in the coders to consistently re-code the same data corpus, exactly the same way over a period of time; reproducibility criterion is accomplished once a group of coders have reached a tendency of classifying categories in a similar way; and the latter, accuracy is the level that the categorisation of the data relates to a defined standard (Lewis, *et al*., 2014).

Validity has been defined as what grade of acceptability and accuracy a research outcome has achieved (Lewis, *et al*., 2014). Seale (2012) has described three elements connected to validity and that are part of the scientific tradition: measurement validity, which is the extent of a measure to capture the concept that it intends to describe; internal validity, how well supported casual statements are by the study itself; and external validity, the level that the findings of the study can be generalised to populations or to other settings.

The subsequent steps in the method are the analysis, interpretation, and final presentation of the results (Schreier, 2012) (see figure 3.4), giving specific emphasis over the first two and last steps of the method. In addition, despite the data and research question, the steps that are followed when using QCA are the same (Schreier, 2012).

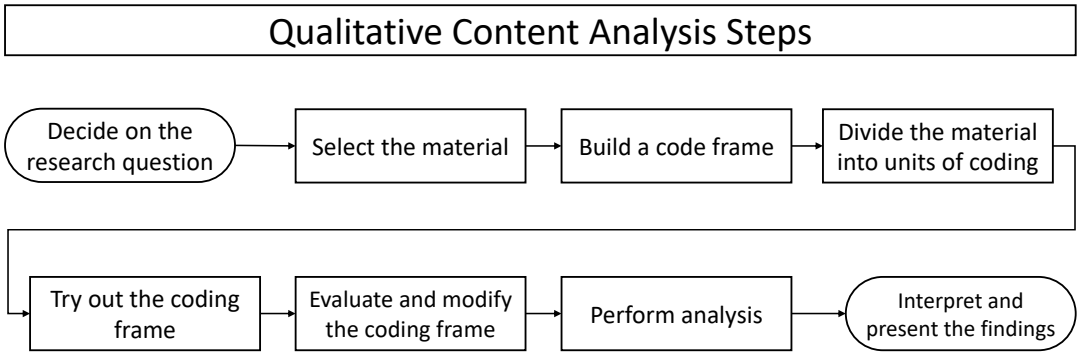


Figure 3.4. Steps in Qualitative Content Analysis

Additionally, QCA is one of the qualitative methods used to analyse substantial amounts of data that come from different domains.

As one of the limitations that Qualitative Content Analysis could have, the categorization of the text based on preestablished theories might downplay the view of the content as it is, instead of opening the richness of meaning of the data that is yet to be exploited, and that could potentially lead to an in-depth analysis (Mayring, 2000). Also, the use of paraphrase to explain the data could imply that important insights might be missed as basic and essential text is replaced (Flick, 2018).

Besides, when using QCA, the research question should point out the direction to examine the data, and in the event that any other relevant aspects emerge, there might be the need to change the framework to incorporate these (Schreier, 2012).

Qualitative content analysis is recommended to be used to answer research questions that relate to the study and sample of large amounts of text, where for example a researcher is elucidating and trying to: understand the goals, motivations, and communication patterns of individuals, groups, and organizations; explain how people respond to messages, both emotionally and behaviourally; determine the psychological or emotional state of people or groups; analyse interviews and open-ended questions to supplement quantitative data, and even, when time and resources limit the ability to conduct focus groups or interviews (Forman & Damschroder, 2007).

3.3.1.2 Discourse Analysis

Discourse Analysis (DA) is an approach that can be used to identify a group of ideas or patterned ways of thinking in written texts and verbal communications

(Powers, 2001). Also, discourse analysis produces insights regarding the effects of a discourse within a group of people, categorizing the subjects into leading and following characters based on their attitudes and positions.

Typically, discourse analysis starts with a deep reading and rereading of the data (Woods, 2014). It is during these processes, that the analyst will be able to notice some details that, potentially, could lead to draw systematic patterns within the data (Albertín Carbó, *et al*., 2016).

Although there is not a standard approach to discourse analysis, Tonkiss (2012) has proposed a general framework that could be followed when applying discourse analysis. Figure 3.5 below presents the general steps that could be followed when using discourse analysis as the qualitative method chosen.

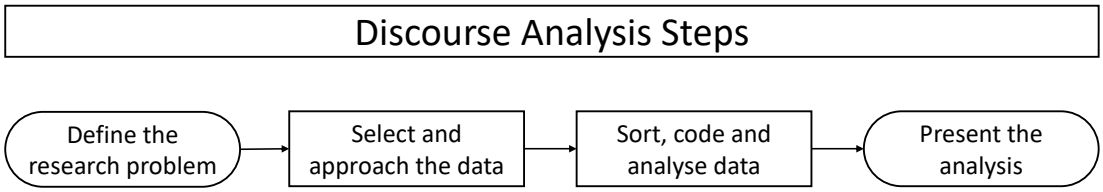


Figure 3.5. Steps in Discourse Analysis

As a result, it has been said that the methodological propositions on to how apply discourse analysis are imprecise and implicit in the literature, suggesting that theoretical claims and empirical results are dominant in the publications (Flick, 2018). Additionally, discourse analysis is commonly used with small data sets that come from particular social settings such as political speeches, legal or medical discourse, talks, and private conversations (Tonkiss, 2012).

Consequently, being discourse analysis a method that is typically applied to small data sets, it was encountered as one of the main limitations when trying it out, finding it not suitable for what the research envisaged.

3.3.1.3 Thematic Analysis

Thematic Analysis (TA) is a qualitative method for the identification, analysis, and later report of common patterns (also known as themes) inside data (Fereday & Muir-Cochrane, 2006), and applied in a wider range of styles rather than in a single qualitative analytic approach (Braun, *et al*., 2019). This method is also known as a qualitative descriptive method (Vaismoradi, *et al*., 2013).

Thematic Analysis offers a greater theoretical flexibility and freedom, as it presents a method for data analysis without prescribing specific approaches for data collection, theoretical methods, or an ontological framework (Braun & Clarke, 2013; Clark, *et al*., 2021); thus, it could provide more foundational insights over other related approaches (Braun & Clarke, 2006).

Furthermore, Thematic Analysis is one of the most appropriate techniques to use when the data corpus is extremely rich, which is the case of the data that have been collected for this research, where verbal interactions have been recorded (Braun & Clarke, 2013). Also, generalisation in TA is based on cases and groups comparisons related to specific issues, pointing to the construction of theories; however, this seemed like a limitation of the method, restricting the scope of the theories that could be proposed. (Flick, 2018).

Thematic Analysis approach

Given the fact that the data corpus that has been collected as an essential part of this research is based on audio and video files, these must be transcribed to allow the interpretation of the students' interactions taking place. Section 3.5.1 of this chapter will describe in much more detail the transcription process.

Once the data have been transcribed and ready for analysis, in Thematic Analysis a six-basic-step methodology is followed to approach the data (Braun, *et al*., 2019). Figure 3.6 briefly sketches the method that is applied, and that will be explained in the following paragraphs.

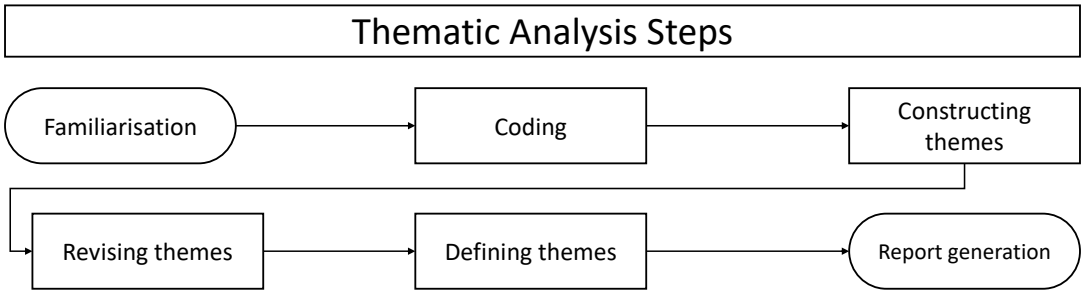


Figure 3.6. Thematic Analysis Approach

The first step of the method is **familiarisation**. This could be seen as the most important phase of the approach, where the researcher should experience an immersive process, establishing a connection with the data, fully engaging,

annotating, looking for what is noteworthy and, if possible, starting to establish connections and coincidences across the utterances (Silverman, 2011). In addition, the familiarisation process means to go over the data as many times as needed, rereading the transcriptions, with the purpose of spotting features that might have not been seen during earlier stages of the analysis.

When moving to a more comprehensive and methodical strategy, **generating codes** – which are labels assigned to data sections – as the second step, starts playing a vital role. It is here where the attention and focus on the data should be thorough and strict to make sense of the interactions (Braun, *et al*., 2019), and thus, to come up with the identification of meaning across the whole dataset.

Two general perceptions have been developed for coding: **inductive and deductive**. In inductive coding the researchers start the analytic process from the data, which is commonly understood as a 'bottom-up' approximation, without incorporating ideas from any other environment (Fereday & Muir-Cochrane, 2006). The other perception is a deductive orientation, where, usually, the researcher uses the data with already well-known concepts, theories, or previously defined codes that have been used, applying them to the data corpus (Saldaña, 2021).

The third stage is the **construction of themes**, which could be seen as the continuation of the previous step, but with the implication that at this point the themes are assembled, shaped, and a meaning is given for the data crossing, the experience of the researcher, subjectivity, judgment, and the research question (Gray & Jensen, 2022).

The fourth and fifth stages, **revising and defining themes**, are related, since at this specific point, the themes that have been created in the previously mentioned stage are simply proposals, which means that some of them might be skipped, and others could be modified to supply the needs of the research (Braun, *et al*., 2019). This is a continuous refinement process, looking to satisfy the scope of the research while maintaining the limits of it; thus, capturing the meaning of the data, and what in reality wants to be represented (Clark, *et al*., 2021).

Finally, **producing the report** could be thought as a merely writing-up process; nonetheless, it is at this point, where it could be seen how the themes flow, individually and in general (Bryman, 2016). Therefore, it is advised to revise the research

question, earlier definitions, and annotations; also going back to certain steps of the methodology, such as the familiarisation, coding, and themes definition, ensuring that the themes stay grounded on the data, and address the research question (Gray & Jensen, 2022).

Also, while the steps of the method have been presented in this order, they do not necessarily follow this sequence, given that the nature of the process is very dynamic and active, rather than a linear sequence (Clark, *et al*., 2021).

Consequently, as part of the exploratory processes that have taken place along this study, initially, Qualitative Content Analysis has been used and applied for the interpretation of the data; however, due to the limitations and constraints that were encountered as the study was developed, the complexity of the transactions and exchanges among the students in the teams, and what the research had aimed to, it was found insufficient.

Braun and Clarke (2019) have recognised that Thematic Analysis can be framed as an umbrella approach, under which reflexive thematic analysis sits. As such, it is through reflexive thematic analysis that the researcher's interpretative analysis intersects in the data corpus, the theoretical assumptions of the analysis, and the analytical skills or resources of the researcher (Braun & Clarke, 2019).

Thus, as a former engineering student myself, it may well be that I have navigated to certain aspects of the data – aspects that I was more familiar with or enjoyed more when I was learning – than others; for example, I gravitated more towards sections where the discussions were more oriented towards the definition of a specific chemical process, issues around selecting a location, or when there was a learning aspect that implied that shared-regulation of learning was apparent.

As a result, reflexive thematic analysis was then applied and selected for the generation of themes, themes that could capture the richness and complexity of the data corpus; consequently, reaching a much robust assessment of the interactions that have been taking place within the teamwork setting.

3.4 Data collection

This research is exclusively based on audio- and video-recording footage of multiple sessions from each of two groups of third-year-undergraduate students while

undergoing project-based learning sessions. The students, who have participated in the sessions, are all attending the CP306 Process design and Simulation module, which runs during semesters 1 and 2, and is part of the chemical and process engineering program offered by the University of Strathclyde. Footage was collected during the 2017-2018 and 2018-2019 academic years.

The following subsections will present some considerations that have been reviewed and adhered to for the data collection process.

3.4.1 Naturalistic data

Capturing naturalistic data as is, is an essential element to recognise features of autonomous behaviours (Potter & Shaw, 2017), which might or might not be displayed by the students in a setting, where the absence of a tutor is of significant relevance, since they can behave normally as they usually do (Järvinen & Meyer-Mik, 2020).

As an extensive video and audio footage has been recorded, it is crucial to mention some of the advantages and disadvantages that naturalistic data can offer.

A. Advantages of naturalistic data

Naturalistic data provide a closer approach to the phenomena that are the focus of the study, where diverse situations, instead of being static, flow, change, and evolve over time, and are directly affected by the circumstances (Cohen, *et al*., 2011). Furthermore, naturalistic data are vivid evidence of individuals interacting with each other, chasing goals, dealing with tasks, and sharing thoughts and experiences (Potter, 2011).

Equally important is the fact that video and audio recordings have allowed a better comprehension of the dynamics that could emerge as students work through the diverse tasks, allowing the researchers to revisit and rewatch the clips as many times as necessary (Hartson & Pyla, 2012), which is also relevant to the process of providing reliability to the interpretation and analysis of data by different researchers (Silverman, 2011).

Besides, naturalistic data have the enormous potential of leading the researcher to unknown issues and interests that might not have been considered or even projected

at the research proposal stage and/or the beginning of the research itself (Potter, 2008).

Additionally, due to the richness of naturalistic data, specifically audio and video recordings, their validity could be much easily assessed under the framework of qualitative research, involving careful testing and consideration for reliability of analytical claims (Peräkylä, 2011).

B. Disadvantages of naturalistic data

On the other hand, it is well known that the presence of the researcher or an outsider might potentially cause an alteration to the natural behaviour of a group of people, consequently influencing the way individuals could act as a series of activities or tasks are undertaken (Mehl, *et al*., 2012). As a result, it could end up generating data that are not authentic, although, the individuals are being observed in a natural environment (Miller, 2019). Furthermore, individuals may change certain normal behaviours or manners for those that fit in or are seen as acceptable from a social point of view (Cherry, 2019).

In addition, there is a limitation of what information video cameras and audio recording systems are able to capture, which could be directly linked to the fact that what happens outside the video recording setting is completely unknown for the researchers; therefore, there is no way to identify the extent of the implications on the behaviours and decisions of the participants (Potter & Shaw, 2017).

Further details about the collection process are introduced in the following subsections.

3.4.2 Ethical considerations

Data that have been generated and used as part of this research have been granted Ethical approval by the Departmental Ethics Committee of the Chemical and Process Engineering Department. Also, the study has used audio- and video-recordings from a previous study with the same setting (i.e., participants in PjBL groups during project meetings), which had been already given ethical approval.

To protect the integrity of the participants and the research itself, four essential elements have been considered for the administration and handling of the data:

informed consent, anonymity and confidentiality, and the protection of the participants from any detriment (Ritchie & Lewis, 2003).

A. Informed consent

A written informed consent was obtained from all participants (see **Appendix 2**). A form document was provided to every single participant, where it was undoubtedly stated the purpose of the research, what the participation would entail, who funded it, people involved in it, how the data would be managed, used, processed, and stored, and who would have access to the material.

Also, to emphasize the fact that participation was voluntary, and if at any point they would like to withdraw their participation, there would not be any problem, and the material, whenever they have had any appearance, would be disposed of (Silverman, 2011).

This consent form was filled in and signed by each participant, so their agreed participation was written and formalised as part of the ethical and data protection regulations.

Furthermore, a participant information sheet was given to every participant, where it has been stated that stills from video footage may be used in academic presentations or publications as part of the research and future dissemination; therefore, their visual appearance will be visible in such pictures. Additionally, it was said that short video clips may also be used for academic events, where it is important to understand the visual and verbal aspects of social interaction in group work. This participant information sheet was also filled in and signed by the students (see **Appendix 3**).

B. Anonymity and confidentiality

Identities of participants have been paramount of this research. Keeping anonymity of whom they are, what they have said, and what kind of interactions that are not relevant or connected to the core of this study have been kept to the utmost. Consequently, all participants have been given pseudonyms so their real identities would never be disclosed, and so, any attribution of comments made by them could be avoided, thus, maintaining anonymity (Ritchie & Lewis, 2003). Additionally, files have been labelled in a way that no information related to participants could be connected, preventing that anonymity could be compromised at any given time.

Due to the type of data that have been gathered, where students have been audio and video recorded, there is a high probability that as the meetings took place, students have had conversations or even discussions about topics that at some point were not directly connected to what the actual focus of the meetings were and the tasks entailed, and in doing so, some information or comments regarding a variety of topics could have been expressed (i.e., personal issues, explicit reference to members of staff, and even researchers), raising ethical issues that could have not been initially considered.

Therefore, to prevent the possibility that any connection could be established between what students have expressed or in the hypothetical event that could be disclosed, confidentiality has been at the core of this study (Lowrance, 2012); however, interactions that have included any mention or signalling any information that was not connected to the focus of this research has been transcribed, marking those instances as 'off topic' as they were not relevant to the core of the study.

In addition, it is worth mentioning that the interaction between students and researchers has been exceptionally low during the audio and video recordings of the meetings. Sessions have been held with a light support and in the absence of any 'outsider', with the main purpose of neither altering nor influencing the nature of the conversations happening in the room.

C. Protecting participants from any detriment

This being a setting where participants were to be video and audio recorded, there was certain hesitation of volunteering to this purpose. Consequently, participants were made aware of that their grades would not be affected by taking part in the study. Similarly, there was some concern about the leading lecturer of the module having access to the videos, making clear to them that it would be impossible for the lecturer to see the videos as they would be raw data while they were attending the module, and if that happened that event would never affect their grades.

Finally, any possible risk and detrimental effect on the participants were almost absent given the considerations and mechanisms in place to avoid any detrimental effects on the study experience of the students.

3.4.3 Audio- and video-recording

The core source of data for this research are audio- and video-recording files of students' project meetings. The data corpus is entirely made of nine meetings that have been video recorded, with an equivalent of 18-filming hours of actual work. From these figures, around 11 hours have been transcribed, which have been the equivalent time students have been focused on the tasks and project activities. The remaining 7 hours have been the time that the students have been mainly off-task, talking about matters unrelated to the project assignment.

As it could be seen in figures 3.7 and 3.8, the room presents what an exemplar video and audio recording setting looks like.

Figure 3.7 Exemplar video and audio recording setting (a)

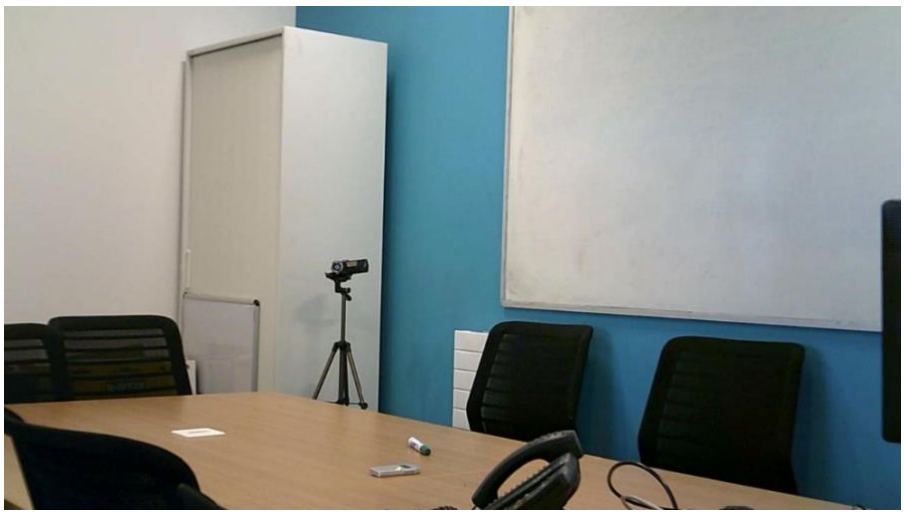


Figure 3.8. Exemplar video and audio recording setting (b)

In the room images 3.7 and 3.8, two video cameras have been set up at opposite sides, typically, in a meeting room; an audio recorder has been located, usually, in the middle of the meeting table as an acoustic gadget for voice recording, as it captures much clearer voices and interactions, which for the purpose of the transcription process has been of a significant support. The use of an audio recording device has helped overcome one of the video camera limitations of sound recording.

Figure 3.9 shows a snapshot of one of the teams while working on the project assignment, where it could be seen some of the members having some sort of interaction as the meeting is taking place.

Figure 3.9. Students working during a project-based learning meeting

Once the sessions were over, the equipment was collected, and files were immediately transferred to an encrypted remote drive and a password-protected external drive for categorisation, standardisation, and further processing; the data management stage is further explained and expanded in section 3.4.5.

3.4.4 Participant recruitment

Participant recruitment could be one the most important activities of this research. Students who have voluntarily taken part in the audio- and video-recording process, must be registered for the CP 306 (new code CP 327) Chemical Process Design and Simulation module, which has been led by the head supervisor of this research, based in the Chemical and Process Engineering Department.

Figure 3.10 presents a usual classroom setting for the subject that has served as the framework for the video and audio recording sessions. Here, students can be seen working in their groups after the main plenary session has been held by the head lecturer of the class.

Figure 3.10. Common classroom setting

Initially, for reaching the recruitment purpose, the lecturer of the module made an announcement during the first lecture weeks of semester 1, as the class takes place during the whole academic year – covering both semesters – , asking for student participation, mentioning the purpose and nature of the study to be conducted, and making clear that participation was voluntary, noting that there would not be any detriment nor effect towards class marks or even attendance (see table 3.2 for reference).

Table 3.2. Characteristics of students' cohort

Cohort	Group	Number of students	Cohort size	Allocation
2017 – 2018	3	5	143	According to Belbin (2010)
	4	6		
2018 – 2019	5	6	127	Aleatory

Once some of the students have decided to volunteer, either by reaching out to the lecturer or researchers via e-mail, or face-to-face, and agreed to be part of the audio- and video-recording sessions, they have been provided with much more detailed information about the research, what it entailed, and making clear if they decided at some point to opt out, this would proceed without any issue.

Moreover, it was said to them that a different room to the lecture room was to be booked and used for the recording of the sessions to avoid any noise and disturbance that could be caused by an external source or an individual in a common classroom. Thus, the students' groups would be allocated in separate rooms, which was one of the 'selling' points for the audio- and video-recording, where they would have access to boards and in some cases a desktop computer with some projection equipment to support their teamwork.

The groups that have been observed are made of five to six students each. The following table (3.3) brings a complete list of the participants that have made up the two groups:

Table 3.3. List of participants and data collection

Cohort	Group	Members pseudonyms	Sessions	Hours of footage	Date of recording
2017 – 2018	3	Jamal Aaron Conor Fred Richard	5 sessions Each session 2-hour duration (approx.)	10	January – March 2018
	4	Emily Liam Adam Nick Robin Grant	4 sessions Each session 2-hour duration (approx.)	8	January – March 2018

Also, groups were created in the virtual learning environment (VLE) of the University, and a specific space within it was assigned to the members of each group,

where they could post any questions and have discussions related to the assignment, in addition to the official communication channels with the lecturers and tutors.

3.4.5 Data management

A data management plan has been structured according to the University regulations to secure the integrity of the footage that has been collected for this research (see **Appendix 4**).

The data management plan sets the guidelines for the administration of the files along their lifecycle of the research. Files have been stored in an encrypted drive administered by the Information Technology group of the Chemical and Process Engineering Department, where access has been restricted and exclusively granted to the group of researchers, who have been involved in this study. Also, an external password-protected hard disk has been used to store a copy of the files, serving as a backup in case of unexpected events. Moreover, a database file has been created, where the files collected have been registered, listing the name of the file, type, and duration.

In total, 86.5 hours of audio and video footage of students' work has been captured from both streams in the meeting rooms. From these figures, around 49.5 hours of footage have been audio and video recorded during the execution of this research, which corresponds to the project-based learning sessions held during the January-April 2019 period. The rest of the material, equivalent to 38 hours of the data, was recorded during the same months from their respective years, which have been produced in previous academic years by other researchers of the Department of Chemical and Process Engineering, members of the SkIL (Skills, Interactions, and Learning) Research group (Potter, 2008; Mabley, 2020; McQuade, 2020).

3.5 Data analysis

Self-regulated learning strategies such as self-evaluating (i.e., I check my assignment to make sure it was right), goal setting and planning (e.g., I start preparing my exams 2 weeks before they happen), organising and transforming, seeking information, keeping records and monitoring, among others (Zimmerman, 1998), that potentially could be shown by participants are going to be analysed and compared,

based on the type of language and phrases used within the different sessions, this to start describing common characteristics indicating learners' autonomous behaviour.

As it has been presented in section 3.4.3, this study has used naturalistic data of teams of students while carrying out project-based learning meetings via audio- and video-recording (~38 hours). These data have enabled the identification of elements of regulatory behaviour as displayed through language and interactions.

Figure 3.11 illustrates the stages of the data collection and analytical approach as they have been covered by the research under the proposed method. Note that video and audio recording are at the centre of the research, being two of the most important components to be analysed. The elements displayed here are further explained in the upcoming paragraphs.

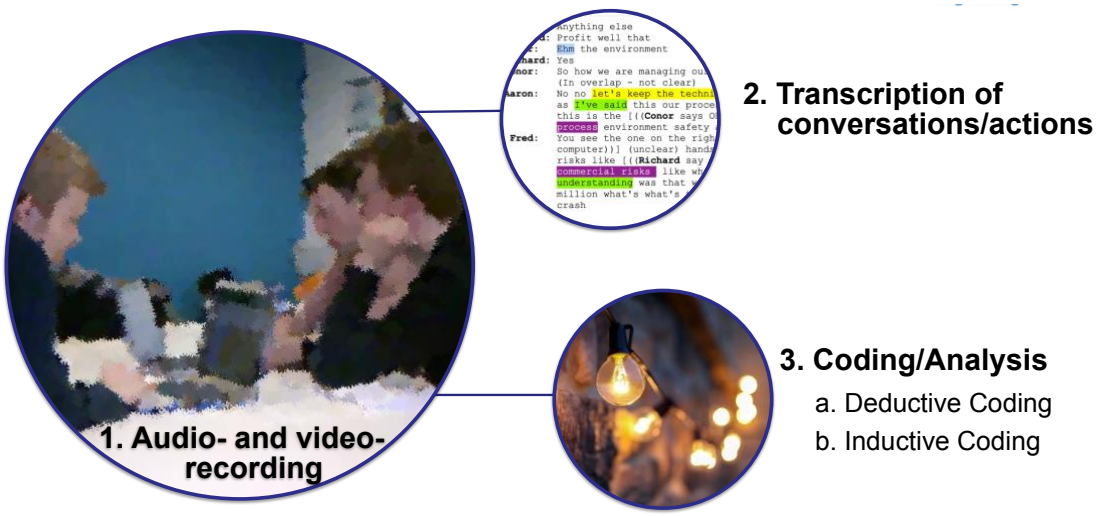


Figure 3.11. Applied methodology

Since video recordings give an unfiltered reflection of action, they are more powerful than merely human observations (Cohen, *et al*., 2011). Moreover, video recordings can be played numerous times, allowing the researchers to obtain detailed evidence from students' interactions (Jordan & Henderson, 1995), which can be analysed using categories identified within the literature.

Finally, the use of video footage will also allow the coding of actions, for example, non-verbal behaviours, and a broader range of teams to be studied and subsequently, provide conclusions for a wider range of cases (Cohen, *et al*., 2011).

From the video and audio footage, an orthographic transcription has been executed of the speech of all participants participating in the meetings (Braun & Clarke, 2013). The next section will describe in detail the transcription process.

3.5.1 The transcription and coding process

Transcription is one of the most complex tasks to cover as part of the research. Here a speech representation of the participants' talks is going to be written, where verbal (full transcription of speech, including errors) and non-verbal data (i.e., gaze and gestures) will be collected (Bloor, *et al*., 2001). The orthographic transcription and the coding are two fundamental steps for the development and proposal of a set of common patterns (Braun & Clarke, 2013), which could lead to a framework definition (Braun & Clarke, 2006) that suits the data corpus.

A. Orthographic transcription

The orthographic transcriptions of the oral speech have been carried out and the transcripts have served as the principal data corpus for the analysis. The transcription has been completed following the golden rules of transcription mentioned by Wiggins (2017), particularly, applying the one which refers to no use of punctuation as it would be carried out for a written text; this might seem a bit strange when thinking about the fact of not giving space to normal pauses, exclamations or even questions as the students talk.

Consequently, the use of punctuation could alter the meaning of what it was said, incorporating elements that might have not been present when the interactions happened and that could be perceived as an assumption of the transcriber. Additionally, Courier New type font has been used given that its uniformity helps keep the characters aligned, allowing the transcribe to make handy comparisons and edits.

Therefore, it is crucial that dialogues are transcribed as they are said by the students (Cohen, *et al*., 2011), which will avoid any addition of elements that could not be present as part of the interactions, and potentially lead to the decontextualization of what has been said, ending up with mistaken interpretations (Braun & Clarke, 2013).

Also, as the students' interactions tend to be vivid as part of the dynamic process, it has been a common element that more than one person speaks at the same time, reason why in the orthographic transcription, those utterances have been put into

double brackets to make a distinction between the person who has been intervening and the one who has made his or her opinion heard. Similar use has been given to any extra information that could add a bit more of context to the interactions happening.

Another significant aspect of the transcription process is the fact that sometimes what is said or talked by the participants is not clear, there is overlapping while talking, the quality of the audio recording is not the best, and even, the video recording file does not have good audio. Hence, the word *unclear* has been used as a filler in these events, appearing along the excerpts in several places.

Consequently, the orthographic transcription process has only captured the speech, and if relevant, perhaps some references to elements that could support the discussion.

B. Coding

Once the transcription has been executed, the next step is to group the video transcription elements into defined SSRL (Shared Regulation of Learning) categories identified as codes, which are just names given to an utterance that comprises an idea or information (Cohen, *et al*., 2011; Saldaña, 2021), such as task knowledge, collective goals/standards, team member negotiation, strategy knowledge, motivation and emotions, perception, and evaluation of progress.

This stage is known as coding, which, as defined by Saldaña (2021), is one way of analysing qualitative data, and where a category label is assigned to a piece of data (Cohen, *et al*., 2011); to finally analyse the spectrum as a whole, and in this way build a robust model that has enough elements that supports the SSRL model.

Initially, a deductive data- and theory-driven framework was established, which has taken Zimmerman's (2008), Hadwin *et al.'s* (2011), and Schoor *et al.'s* (2015) studies as the bottom line to start the data analysis process. As such, this framework was intensively explored, analysed, adapted, and utilised during the very first research meetings, trying to generate an analytical structure that could potentially suffice the needs and aim of this study.

Nonetheless, after several attempts trying to use the SSRL categories in conjunction with Schoor's (2018) framework across the data sessions and discussions, it was

soon proved that this approach was not suitable for what was intended, aspect that will be discussed in section 4.1. The theory-driven framework was hardly suitable for what the research has originally conceptualised and visualised to be the final research product. The students' interactions and transactions were poorly allocated, there was a lack of description of what was displayed by the groups of students in the meetings in terms of shared regulation of learning that such as SSRL model could explain.

As a result, the need of a different methodology to scrutinise the data corpus soon emerged; hence, the process had to be reverted to a full data-driven approach, applying an inductive method, which will be later described in **Chapter 5**. It is under this singular perspective that a new structure was conceptualised and devised.

Subsequently, under this innovative framework an intensive exploration and data analysis have taken place; the data excerpts have been discussed, amended, coded, and scrutinised. Nonetheless, the analysis has still considered and used theories and concepts of self- and shared regulation that have been proposed and developed by Zimmerman (2008), Järvelä and Hadwin (2013), and Hadwin *et al.* (2018), with the incorporation and adaptation of the research executed by Schoor *et al.* (2015) and Schoor (2018), so that a more suitable framework has been conceived.

Additionally, since the data corpus is extremely rich in terms of exchange of ideas and interactions among the participants, the new framework has suffered several alterations and adaptations to fulfil the needs of the research, being this a dynamic and continuous process across the research meetings, known as data sessions, which are described in the following subsection (3.5.2), reaching a point where a more robust framework has been achieved.

3.5.2 Data sessions

Data sessions are a series of meetings held from time to time, where specific parts or extracts, taken from the video and audio transcription, are explored and validated by a group of researchers.

Data sessions are one of the most useful techniques to get a better comprehension of the dialogues transcribed from the students' meetings. As first instance, they serve as the perfect scenario to check the first block of the transcription, allowing the researcher to get support, and a unique perspective of how the identification process

of the elements, which are embedded and concerned the transcription, should be allocated according to the proposed model, enhancing it, and thus, making it more appropriate to the aim of the research (Wiggins, 2017).

Relevance of data sessions

Data sessions are an important and probably, the best way to assure that what has been written is close enough to what certainly was said by the students. A data session, usually lasting about an hour, is where excerpts of the transcription are shared, explored, and coded according to the scheme that has been proposed. Each excerpt corresponds to between 1.5 and 3.5 minutes of video footage. In these sessions, the extract is accompanied by audio and video files, which are meant to be encompassed by the text, so a double-checked process takes place, where the initial transcript is usually amended, if any transcription errors are detected, as the coders listen again to the original speech.

Data sessions take a significant relevance for the corroboration of what has been transcribed, since having a double-check process assures that the elements are valid, and the transcription is close enough to what was said by the participants; hence, the quality of the transcription is considerably improved because of this process. It avoids misinterpretations, making it reliable and concise, and that the elements which have been identified through the speech are similar to those coded by other researchers (Wiggins, 2017).

Also, transcription process could be seen as one of the most challengeable tasks, as the students' speech speed poses a significant difficulty to follow while transcribing their interactions, where overlaps in their interventions are frequent, the audio quality of the footage is not the best, and sometimes, students' voices are at a low volume level, almost impossible to perceive.

One other advantage of the data sessions as they have been conducted in this research, is that they allow the researchers to establish reliable interpretations as all participants discuss and agree upon the interpretation and coding of the data. This provides robustness to the interpretations and analysis.

Through the coding and analysis that have been carried out in the data sessions an initial scheme can be formulated. This scheme can then be developed in subsequent

data sessions as an essential part of the iterative nature of this process, where sometimes the research team have come up with new codes that later needed to be incorporated in the scheme, thus, modifying it.

In the data sessions, the initial proposed scheme, which will be presented in the results chapter, has been used as the preliminary framework to identify instances connected to autonomy and key elements on how the students organise the different activities, tasks, and manage their time. Besides, it has been seen how the teams deal with different situations, such as disagreements, which could arise within the meetings (McQuade, *et al*., 2017). In addition, an essential element of the process has been the adaptation process of the coding scheme that has been formulated after an intensive exploration of the data, and subsequently, the coding scheme has been tailored to serve the research.

Furthermore, data sessions play a vital role in the identification and validation process of the elements or themes that have been categorised using the scheme. Therefore, different researchers, typically, identify similar elements across the extracts, which are connected to the study. When this is not the case, i.e., specific instances seem to differ, a further exploration and discussion stage takes place to validate the structure, consequently, an agreement is reached; hence, a common element that suits the purpose is used to allocate the section or sections that were under discussion.

Also, the data sessions were an essential element to evaluate how reliable the scheme was, as the researchers who have been involved in this study have been using the same framework, coding independently the excerpts during the different data sessions, reaching similar results in the great majority of cases (Clark, *et al*., 2021), replicating the findings of the research (Gray & Jensen, 2022), which was an element witnessed when discussing the extracts.

Additionally, as mentioned by Schreier (2012), keeping consistency and a systematic coding frame are two of the most important aspects when checking the reliability of a qualitative research. For building coding consistency, two ways have been proposed, another person codes the material that one has coded, or after about 2 weeks of having coded oneself the data, the process is repeated by oneself, where if reaching similar interpretations of the material, then, it could be said the coding frame is reliable (Bernard & Ryan, 2010), without claiming that this might be the only and exclusive meaning of the material but that researchers have reached similar conclusions

(Schreier, 2012). Finally, in doing so, doubled-coding is an effective way of assessing the quality of the coding frame, assuring that the meanings of the codes are clear and there is no overlap among any subcategory (Clark, *et al*., 2021)

During the data analysis process, 64 data sessions have been held, offering a valuable and unique setting for the allocation of the excerpts into the elements of the model, where vivid discussions were held, shaping the research, proposing modifications to the framework, addressing issues, and redirecting the studies when things were blurred.

3.6 Summary

This chapter has presented the theoretical framework that has been used during this research and influenced the conceptualisation of the study.

It has collated the project context of the assignment that the students have gone through along the video and audio recording process, which has been an essential and influential element of the way the conversations and interactions have occurred, serving to undertake this study.

Also, the chapter has discussed the research methods that have been applied for the construction, analysis, and configuration of the outcome of this research, introducing the nuisances that have been faced while proposing a shared regulation of model.

Furthermore, it has shown how the data corpus has been used, the relevance of the data sessions as the principal setting, where the guidance of experts has played a vital role for the proposal of an addition to the current existing components that have been deeply studied in the area of self-regulation of learning.

The upcoming chapters (**4** and **5**) will present the results and analyses that have been executed in this research, directly connected to the major transactions that have taken place along the students' meetings.

4. Implicit and explicit elements within shared regulation of teamwork

This chapter presents the results from the analyses that have emerged as the data corpus has been organised, extensively explored, and analysed during the data sessions. This has allowed the identification of implicit and explicit elements, which are directly connected to the self-, co-, and shared regulation of learning in the context of teamwork, providing a categorisation for the interactions occurring in a project-group context, which is new to the body of knowledge in the study of shared regulation in teams.

4.1 CASoRL model as a prompt to a new scheme concept

First and foremost, it is appropriate to say that while doing the identification process, some parts of the students' written conversations have been rendered in bold to emphasise its significance for the analysis. It is well known that very often, bold text is used to represent strong verbal emphasis within the speech being made by a speaker as they speak. But here, for this study, its point is to signify its analytic relevance, looking at the meaning of utterances and the significance of that for the progress of the dialogue and the task. Besides, the students' interactions and conversations during the great majority of the audio- and video-recorded sessions have revolved around a chemical process concept-project assignment that has been described in section 3.2.

Initially, the framework that was used to analyse the transcripts was the one that has been proposed by Schoor (2018), and earlier described in section 2.5, thus, serving as the preliminary exploratory structure for this research. CASoRL model first categorises actions (auxiliary level – AL) (see table 2.4) into coding content types such as task definition (td), planning (pl), cognition (cg), regulation (rg), acceptance (ac), coordination (co), and other (ot); and then, actions related to regulation are coded, understood as the assignment of specific labels (Cohen, *et al*., 2011),

underneath the OPES (Operation, Product, Evaluation, and Standard) structure (principal level – PL), consider them from different perspectives: *I, you* or *we* (Schoor, 2018), as it was introduced in table 2.5, and directly associated to self-, co-, and shared-regulation, respectively. For identification purposes within the data corpus extracts, each auxiliary level and facet have been assigned a code as previously associated when listed.

Additionally, before entering into the scripts analysis, it is relevant to state that although the model suitability to understand students' transactions and interactions, that initially was thought to be the appropriate for the data corpus of the research, it was realised the limitations and constraints of it, and how difficult the identification of the elements of this model within the data was; however, the work that has been done during this explorations and discussions is reported in this chapter.

In the following section, some extracts from the data corpus that have analysed across this research are going to be discussed. Although, the focus groups and their members have been already introduced in table 3.3, it is useful to reintroduce them again as a reminder before any analysis is started. **Group 3** is made of five students, **Aaron**, **Jamal**, **Conor**, **Richard**, and **Fred**; and **Emily, Liam, Adam, Nick, Robin,** and **Grant** are part of the **Group 4**. These two groups, who have been observed repeatedly across multiple sessions, have had fluent and vivid interactions and discussions as the project meetings have taken place.

Extract 4.1.1 presents an example of the exploratory process that has taken place in the attempt to use the CASoRL model; as indicated by the model, the segments have been labelled first, under an auxiliary level, and then, assigned a principal level, which were given based on the incidence of a perspective element, rendered in bold for identification purposes as previously indicated. In addition, some students' utterances have been labelled under different auxiliary and principal level, showing the complexity of the interactions and the difficulty to draw a border between the facets.

Extract 4.1.1. Group 3 – 15.58 minutes into the meeting 2 out 6 – (241019)

Line	Student	Utterance	AL	PL
1 2	Aaron:	**I think we're just producing** that this nitric acid plant basically	**pl**	**O** **P**
3 4	Richard:	so that's like **we're producing** nitric acid for	**ac**	**P**
5	Aaron:	**we're producing** nitric acid for the	**cg**	**P**

Line	Student	Utterance	AL	PL
6		explosives industry in Australia		
7	Conor:	and **I'm sure** mining	**rg**	**P**
8	Aaron:	no no no no		
9	Richard:	mining (laughter) metrics		
10 11 12 13 14 15 16 17 18 19	Aaron:	**I'm close** and **I hope we're** good anyway location capacity sort with stuff like that **I think then you can** **go see** though **I don't know what** **we're gonna do if you wanna 'cos I** **think** ((**Fred** says I like that)) with that worth what technology of the actual design of **the plant is the** **most important part of stage** 'cos that's the key to the presentation	**rg** **co** **rg** **co**	**E** **O** **O**
20 21 22	Richard:	**we need to justify why we're not** doing it in the agriculture or in India and China	**rg**	**P**
23 24 25 26	Fred:	oh uhm **I agree I think** like the justification of the location is just as **big as anything else that** **thing right now**	**ac** **rg**	**S** **P**
27 28 29 30 31	Richard:	**yeah 'cos she** (the lecturer) **tried** to stress that point like she she **said why also why you're doing** this process but why **you're not** doing any other process	**ac** **rg**	**S** **S**
32	Aaron:	yeah		
33 34 35 36	Richard:	so **I think** to put it like the reasons **we're doing it** in Australia for the mining industry is because the Asian market is so saturated	**pl**	**O**

In line 1 of excerpt 4.1.1, **Aaron** starts by saying, '*I think we're just producing*', which has been labelled as planning under the operation facet, as he is making explicit use of '*I*' and '*we*' perspective as part of a regulatory process; however, it could be argue that the utterance might also be classified under the *product* facet, causing an issue to what the model proposes, the occurrence of two simultaneous facets within the same intervention, aspect that is not mentioned as part of the indications to use CASoRL model.

Then, in line 3, **Richard** says, '*so that's like we're producing*', which has been classed under the acceptance auxiliary level, and product principal one, respectively, as he restates without major hesitation what Aaron has previously mentioned. Subsequently, **Aaron** in line 5 says, '*we're producing*', being categorised as cognition

as he is talking about the solution of the task but also constructing knowledge as he adds in line 6, '*explosives industry in Australia*', as the industrial sector and location target that their design would be proposed; aspect that is immediately refuted by **Conor** in line 7 by saying, '*I'm sure mining*', utterance that has being assigned under regulation level and product facet. This intervention is replied by Aaron in line 8 saying, '*no no no*', keeping his position regarding the task.

Furthermore, along lines 10 through 19 is where CASoRL applicability starts to fall short, specifically, in lines 12 to 15, where **Aaron** says, '*I think then you can go see though I don't know what we're gonna do if you wanna 'cos I think*', because as instructed by CASoRL model, the use of the '*you*' perspective is directly associated to the appearance of co-regulation of learning; however, the context says otherwise, this '*you*' could be understood as if Aaron were addressing the whole group and not a specific team member; aspect that is directly reinforced by the use of the '*we*' perspective in the same intervention, '*we're gonna*', which could be seen as the application of a shared-regulatory strategy. Instances that have been identified across the data corpus, limiting and constraining the applicability of CASoRL model.

Consequently, in line 20, **Richard** says, '*we need to justify why we're not*', where there is a clear use of the '*we*' perspective, under the regulation and products levels, respectively. A case that does not create any nuisance when using the indications of CASoRL model, but that unfortunately is not seen in all cases as the interactions and transactions take place.

Likewise, the interaction is followed by **Fred**, in line 23 by saying, '*I agree I think*', where there is a regulation aspect under the acceptance and standard levels, correspondingly; nonetheless, these exchanges between Richard and Fred are co-regulation of learning occurrences that might be implicitly happening without the explicit use of the '*you*' perspective, where Richards adds more details to his point of view, along lines 27 to 31, providing elements to the reasons for their decisions; aspect that turned into a certain shared regulation of learning, with **Aaron** saying in line 32, '*yeah'*, seeming to reach an agreement as the meeting continues.

As a result, it has been under these types of exchanges, where the CASoRL model has created a serious difficulty for its applicability without any limitation and restriction as per its instructions, thus, the regulatory events could be classified unrestrictedly.

Finally, in lines 33 and 34 **Richard** says, '*so I think to put it like… we're doing it*', instances that have been put under the planning and operations levels, with the simultaneous occurrence of the '*I*' and '*we*' perspectives, implying that while he is self-regulating himself, at the same time, he is a trying to do a sort of shared regulation of learning to the team throughout his speech.

In the following excerpt, the group 4 have been having an array of exchanges related to the project presentation as one of the requirements for the completion of the assignment. The meeting is well advanced and several elements connected to shared regulation have been displayed along the exchanges that the team members have had.

Extract 4.1.2. Group 4 – 49.06 minutes into the meeting 2 out 6 – (190620)

Line	Student	Utterance	AL	PL
1	Nick:	so **you say** what's going to be in the	**co**	**P**
2		tank is gonna be all is gonna be in		
3		some in some ((**Emily** says some		
4		higher)) higher or the sort in that		
5		area **I've thought we consider** the	**pl**	**O**
6		amount the area of onboard		
7	Emily:	**we can** ((**Nick** says because some))	**co**	**S**
8		but somehow **you need to** explain	**pl**	**O**
9		before the presentation		
10	Nick:	true 'cos it's gonna be part of the	**ac**	**O**
11		storage the difference ((**Emily** says		
12		I mean)) it's big a it's big its's a		
13		big one but **I think** it's not going	**co**	**O**
14		to be something separated (unclear)		
15	Emily:	**I personally won't** think to write it	**rg**	**P**
16		down (laughter) before **we've got**	**pl**	
17		like like less than a week (unclear)		
18	Grant:	before **we can always** say the	**co**	**P**
19		presentation and **you're going to** be	**pl**	**O**
20		like **we're going** to use and you know		
21		actually what **we have to** specify	**td**	**O**
22		where it comes from ((**Emily** says I		
23		know)) and **you know** what to say	**rg**	**P**
24	Emily:	**I'm only** saying **we just need** to be	**rg**	**E**
25		careful on how **we get like** the	**co**	**P**
26		original storage like what **we've got**	**pl**	**P**
27		'cos ((**Adam** says uhum)) **you have** to		
28		try to establish what **we've got**		
29	Robin:	**I'm just thinking** about once **we have**	**pl**	**E**
30		I don't know if **we'll have** time to		
31		do things during or before the		
32		presentation once **we have** the output		**P**

Line	Student	Utterance	AL	PL
33		ehm then **you have** a better idea of		
34		how much like of each things like		
35		how many moles per gallon at each		
36		stage **we will need** and then now **you**		
37		**know** how much water **we will need** and		
38		work backwards ((**Nick** says yeah 'cos		
39		once we have)) or at least have an		
40		average		

Extract 4.1.2 starts in line 1 with **Nick** saying, '*so you say what's going to be*', which has been categorised as coordination and product, where the use of the '*you*' perspective could point out the occurrence of some form of co-regulation; however, the context of the meeting tells that he is not referring to a certain member in particular but to the group as an entity. This instance serves as an example of the difficulty to identify the regulatory phenomena as indicated by CASoRL definitions and guidelines. Certainly, what Nick is aiming to do is to regulate the group, which actually happens explicitly in line 5 by saying, '*I've thought we consider'*, where he uses the '*I*' pronoun reflecting on his own stance and subsequently, use the '*we*' perspective, being much clearer the incidence of shared regulation of learning in the context.

Then, **Emily** in lines 7 and 8 says, '*we can… but somehow you need to*', utterances that have been classed under coordination and standard facet, and planning and operation, respectively, with the occurrence of the '*we*' and '*you*' perspectives, indicating some form of shared and co-regulation of learning simultaneously, which could be explained under CASoRL definitions.

Further down, in line 13, **Nick** says, '*I thinks it's not going to*', which could be seen as a form of self-regulation as he used the '*I*' perspective, classed under coordination and operations facet, but what in reality is happening is a form of shared regulation, where he is trying to influence the team group decision by posing his perception. An aspect that is replied back by **Emily** in lines 15 and 16, '*I personally won't… we've got*', where with her stance through the use of the '*I*' and '*we*' perspectives simultaneously, she goes in counterargument to what Nick has just proposed. Hence, CASoRL lacks an explanation for such an interaction, as the context and use of the pronouns are showing a different scenario to what the model proposes.

Besides, **Grant** in line 18 adds, '*we can always say*', utterance that has been put under coordination and product, as he is trying to organise a strategy for what to say

during the presentation; yet the use of the '*we*' perspective here turns into a '*you're going to*' in line19, and then, returns to a '*we're going to',* immediately followed by '*you know what we have to*' in lines 20 and 21; it is in these intricate interactions, where CASoRL model does not suffice a representation that could rationalise the complexity of human interactions, when trying to influence and regulate others' behaviours; the way Grant uses the '*you*' perspectives is not a sign of co-regulation, but certainly a form of shared regulation, which is what he does when referring to the group with the '*we'* pronoun.

In line 24, **Emily** says, '*I'm only saying we just need to*', which has been classed under regulation level and evaluation facet, with a well-defined attitude towards the shared regulation of the team using her own regulation to then moving it to a shared regulatory stance, shifting from an '*I*' to a '*we*' perspectives; across her speech, through lines 25 to 28, Emily keeps using the '*we*' perspective, which is switched to a subtle '*you*' perspective in line 27 to then, reverted back to a '*we*' one in line 28, exemplifying how the use of the '*you'* pronoun could be associated to the shared regulation of learning, and it is not always related to the existence of co-regulation of learning in the context of team work as it has been suggested by CASoRL model.

Throughout lines 29 to 32, **Robin** starts by saying, '*I'm just thinking about once we have I don't know if we'll have… we have the output*', which have been labelled as planning level and evaluation facet, expressing his idea about the progress that needs to be done to cover the activities, with a sharp intention of shared regulating the team, given the continuous use of the '*we***'** perspective across the lines, which is changed to a '*you*' perspective in line 33, '*you have a better…*', but that in reality is the continuation of a shared regulation phenomena, which is then brought back in line 36 when saying, '*we will need*', and again along lines 36 and 37reverted to a '*you know how much water we will need*', typifying the complexity of the shared regulation of learning processes that happen in a team, where again, the use of the '*you*' perspective in this context does not relate to co-regulation of learning but to shared regulation of learning.

Consequently, due to the inadequacy of CASoRL model to fully explain the interactions and transactions of the groups of students across the project meetings, it was decided to sketch a different strategy to explore the data corpus so a different

approach could explain the distinctive regulation phenomena that have taken place during the students' project meetings.

4.2 Conception of a model scheme

As previously presented, given the data corpus richness and complexity, and the difficulties faced while trying to apply CASoRL model (2018) to the data corpus, soon emerged the need of creating a framework that suited the data and so the research itself. Subsequently, a model associated to Schoor's (2018) study has been proposed for this research; hence, the data could be explored in a more deeply and concise manner, prompting to findings in the shared regulation area.

The model that has been explored in the subsequent sections is made up of three fundamental axes or pillars, which have served to make a grouping of the statements that students' interactions have displayed along with the meetings. The three examined scheme's axes are *Phases, Attitude*, and *Perspective*. Therefore, the definition of these pillars has taken into consideration a series of overarching elements that have been common across the majority of the students' meetings data corpus, and which represent how the conversations and so interactions, as expected, vary from time to time as the students have undergone the project's activities development.

Also, an element noteworthy is that the utterances quoted in the compiled tables 2.2, 2.3, 2.4, and 2.5 from the references are, in most of the cases, made-up by the researchers as it has been reported by Schoor (2015). Real dialogue is often messy and implicit, and these utterances that initially look suspiciously well-formed to be a hundred per cent genuine. This was an issue that has been detected when analysing and discussing the background papers, and it will be further expanded in this work.

The following sections will introduce the major components of the explored model, as they have been conceptualised by Järvelä and Hadwin (2013) and Schoor (2018). It starts off with the *phases* component, then the *perspective* component will be explained, and closes with the *implicit and explicit* elements. Furthermore, the identification and allocation process across the data corpus will be also detailed, within the attempted limited success that the model has had.

4.2.1 The phases component

The first component of the model has been named Phases (see figure 4.1), and has been incorporated from previous studies performed by Järvelä and Hadwin (2013), who have based their work using Zimmerman's (1998; 2008) studies.

Figure 4.1. Phases component – Adapted from Järvelä and Hadwin (2013)

In the *Phases* component, the distinct phases that students usually go through while attempting a task, are a natural process that takes place as the activities as tasks are covered in the conversations.

As it was previously introduced in Chapter 2, Table 2.1 has presented a compilation of Miller and Hadwin (2015), and Järvelä *et al.* (2016) Socially Shared Regulation model approaches, offering a definition for each stage, and in addition, providing explicit conversation examples where the stages have been displayed by participants.

Turning now to the stages, the first one that usually emerges has been called **task definition**, which is the moment when students face the task for the very first time and make earlier analyses (Zimmerman, 2000); the usual second phase is called **goals and planning**, this is the moment when students define aims and a way to achieve them (Zimmerman & Schunk, 2009).

The following stage is **strategies**; this is a critical step because it is when students devise tactics that can help them complete the task. The next element is **coordination**, defined as how the group from a social point of view, manage the tasks needed for the task or project completion (Reimann & Bannert, 2018).

The final element of the Phases component is **standard/adaptation**; at this stage, it is expected that the students have already established a point of reference about their performance and make the correspondent adjustments when the activities or tasks are deviated, and not following the normal course (Winne & Hadwin, 2008).

4.2.2 The perspective component

The next component of the research model is the *Perspective* component. This has been defined as how the student refer to the different actors, internal and external, who might have a direct or indirect interaction in the project completion. When checking the content of the conversations, it has been evident the way students use specific pronouns, *I*, *you,* and *we*, when addressing and interacting within the group, that is why the perspective column (see figure 4.2) incorporates these three elements under a collective concept (Schoor, 2018).

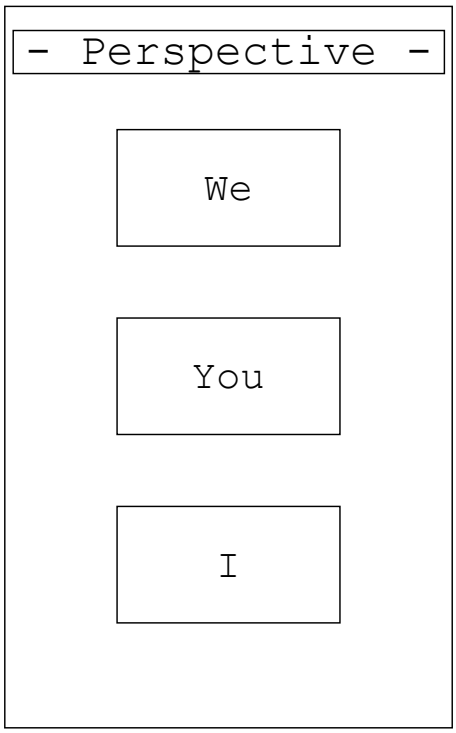


Figure 4.2. Perspective component – Adapted from Schoor (2018)

According to Järvellä and Hadwin (2013) and Schoor *et al.* (2015), the use of these pronouns in the context of group work is a characteristic indicator of regulation, where '*I*' could be pointing out to a form self-regulation during the occurrence of one of the COPES (conditions, operations, products, evaluations, and standards) framework stages; while the use of '*you*', might be identified as a mode shared regulation indicating the happening of co-regulation of learning; and the use of '*we*', as a way of displaying socially shared regulation (Hadwin, *et al*., 2018). These aspects will be analysed in much more detail the subsequent sections.

4.3 Identification and allocation process

As earlier introduced, the *Phases component* is made up of (1) task definition, (2) goals and planning, (3) task strategy, (4) coordination, and (5) standard/adaptation. These five components are described and shown as they have been identified in the excerpts, contained by the limitations that the phases component has posed for the data corpus analysis. Additionally, as previously presented in the anonymity and confidentiality section, names of the participants have been changed for pseudonyms, hence, anonymity is always kept.

Yet, it is worth making clear that although the stages are shown in a specific order, this does not necessarily mean they are going to happen or even be displayed by the students in this particular sequence. In reality, most of the times the phases of shared regulation are, as proposed here, displayed in the conversations without following a specific pattern in more varied sequences.

1. Task definition

Task definition is commonly and has been seen at initial stages of the group meetings, where the students share their individual perceptions or understandings of the task to be accomplished and establish negotiations around task responsibilities (Järvelä & Hadwin, 2013), identifying group strengths and weaknesses (Miller & Hadwin, 2015).

The task definition stage has been displayed in extract 4.3.1, where the students' interactions and discussions have been focussed on one of the requirements that the project asks for.

Extract 4.3.1. Group 3 – 4.3 minutes into the meeting 2 out 6 – (170519)

Line	Student	Utterance
1	Jamal:	**we need a place for feed stock** really really
2		kind of for the grade of feed stock as well
3	Fred:	yeah
4	Jamal:	I don't know if I ever say greater (unclear)
5		before
6	Fred:	do **we need** to put our extraction process in
7		there
8	Jamal:	choose
9	Richard:	I don't know to get a higher concentration,
10		**do we need** 'cos if **we say** like we're gonna
11		use a fertilizer then **we're gonna need** above
12		68%, ((**Jamal** interrupts and says choose))
13		'cos **I need** that part I assume we've only
14		done that part
15	Aaron:	**what do you say** ((*he is taking some notes*))
16	Jamal:	site location

As shown in extract 4.3.1, in line number 1, **Jamal** says, '*we need a place for feed stock',* which gives the group the meaning of interpretation awareness about what they, as a group, should use as a starting point to develop the very first task. This is somehow agreed or at least, followed by **Fred** in line 3 with a **'***yeah*'. These elements lead the conversation to a stage of exchange of ideas in the subsequent lines, which is continued based on their knowledge and probably, prior research about the project activities, giving the impression that was clearly something they had carried out before the meeting, exploring the topic by their own means. Likewise, it can also imply that a strategy has been drawn, making it problematic to assert that is a completely task definition stage.

In line 4, **Jamal** continues his speech saying, '*I don't know if I ever say greater*', which could be seen as a reflection element towards what he has achieved for the task completion. Also, sometimes what the speakers say is not fully understood, this is mainly due to the limitations that either the audio, video recording, or both processes possess, which has been a common feature in the transcription process; thus, in line 4, as **Jamal** continues his speech that at the end is not clear, the word *unclear* is used, as it has been already explained in the orthographic transcription section.

As the conversation follows, in line 6, **Fred** says in a way of questioning, '*do we need to put our extraction…*', giving a purpose to '*a place*' that has been previously mentioned by **Jamal**, which is followed by **Richard** in lines 10 and 11, justifying what

has been mentioned, adding context to the project requirements. In addition, the phrase '*we need'* is used by almost all participants, giving the impression to be related to the fact that the use of '*we*' indicates the ownership of the task by the group identification, with a coordination component that implies the participation of more than one team member to accomplish the task; element that starts to show the difficulty faced when trying to assign a specific phase to a sequence of utterances.

Furthermore, in line 15, **Aaron** says in an interrogating way, '*what do you say*', posing it as a question that could be seen as a form to keep the group members opinion in the loop, but also, it could be argued that when Aaron uses '*you*', he is actually referring to a collective form of '*you*', i.e., the group not a particular individual. This is specifically important as the conversation is quite fluid. However, this could be checked if there are any particular cues of other interactional points: he is looking at his notes, which suggests he is not talking to anyone in particular but the group as a whole. Then again, given that **Jamal** in line 16 says, '*site location*', is not clear if Aaron is talking to Jamal or the group.

Additionally, early in the extract there is evidence of the 'explicit' use of '*we*' to identify the group. However, at the end of the extract (line 15), there is also evidence of '*you*' implicitly, implying '*us*' the collective.

In some of the excerpts that Miller and Hadwin (2015) have used as examples for shared regulation of learning about task perception or definition in groups, these kinds of phrases are also said by participants in their conversations, supporting the fact that students are somehow at that point of the process.

As the meeting goes on, the task definition stage is continued until the team start to move to the next stage, noting that transitions between phases are not always clear-cut and obvious, but that shifts in the dialogue topic result in verbal exchanges that are best classified as part of the next phase; however, this does not necessarily mean they are not going to go back to that phase, since it is neither a rigid nor a strict sequence.

In excerpt 4.3.2, there is a display of the features of task definition among group 3.

Extract 4.3.2. Group 3 – 6 minutes into the meeting 2 out 6 – (170519)

Line	Student	Utterance
1	Jamal:	this is just too hard to find them the

Line	Student	Utterance
2		regional border
3	Richard:	yeah
4	Jamal:	if I were to find 50 grants for our report
5		that would be fine
6	Fred:	yeah that's the issue
7	Aaron:	yeah **I think that percentage was a poor**
8		**investment** limited too much ultimately it's
9		just like if **we build a good plant** as long
10		as our location ((**Jamal** interferes and says
11		as it's not completed)) - it's not concluded
12		before don't building it in the other side
13		of the world (unclear)
14	Jamal:	but **it's just about justification** ((**Aaron**
15		says yeah)) it is not about it's not
16		although **it's not like so we need the**
17		**research backup for** our justification
18	Aaron:	I think we have a quite a few bits I think
19		so
20	Jamal:	I quite a few bits so I think **once we find**
21		**the place we should** maybe **if we say India,**
22		then we'll get more into the - that it's a
23		painful influence 'cos it's a bit flimsy
24		just now

Here in extract 4.3.2, when in lines 7 and 8, **Aaron** says, '*I think that percentage was a poor investment'*, which could be understood as a perception of the task that has been discussed until this point – site location. It has been seen that when **Aaron** in the same speech, in line 9, says, '*if we build a plant'*, is starting to move on the conversation to a *goals and plans setting*, where there is an explicit occurrence of the '*we*' perspective, while he is trying to share regulate the group members.

Yet, **Jamal** brings the conversation back to a task definition stage (line 16) saying, '*we need the research backup for*', as a conception of a collaborative interpretation, making use of an explicit '*we*' perspective, within a team shared regulated framework. However, **Jamal** takes the conversation back again to the task definition stage, which **Aaron** was introducing before, when in lines 20 and 21, he says, '*once we find the place we should… we say…'*, being a distinguishable indicator of planning what could be performed for the forthcoming stage under a shared regulated explicit '*we*' perspective, being three times reinforced, implying that is a task that needs a broaden team participation for its execution.

2. Goals and plans

Miller and Hadwin (2015) have defined this phase in the context of shared regulation as the alignment of personal goals and standards to achieve an agreement around common goals, standards, and plans, leading the group to the successful achievement of the task.

As mentioned in extract 4.3.2, goals and plan stage started to be shown by the students in the group, and it has been continued in the following segment (extract 4.3.3):

Extract 4.3.3. Group 3 – 7 minutes into the meeting 2 out 6 – (170519)

Line	Student	Utterance
1	Aaron:	who was on the site location one (unclear)
2	Jamal:	I don't know I thought ohhh **I don't know**
3		like the market share
4	Aaron:	yeah
5	Jamal:	**we need to start to decide on** market share
6	Aaron:	I did the market share as well
7	Jamal:	and then **we did like the forecasts** ((**Richard**
8		says yeah)) **of the market**
9	Richard:	yeah erm a quite
10	Aaron:	a forecast as well
11	Richard:	a lot of people are doing it in China but **I**
12		**feel like there's so much competition in**
13		**China sorry China is already self-sustained**
14	Jamal:	that chart that I put it in in in the file
15	Richard:	in A10
16	Jamal:	no no in A10 I think it's A12
17	Richard:	(unclear) in A12 it was yeah

In excerpt 4.3.3, elements of task conditions and context are now evidently presented in line 2 as **Jamal** says, '*I don't know like the market share'*, drawing his awareness of task condition, which later in line 5, he (**Jamal**) says, '*we need to start to decide on market share'*, revealing features of goals, providing a context for this target. Additionally, the use of an explicit '*we*' perspective is an example of identification of needs to trigger plans that requires the team contribution.

Järvelä *et al.* (2016) have provided a good example connected to goals and planning context, where the shared planning component is displayed by the participants of their study as they use words such as start, progress, and integrate, which are related to this period of the students interactions. Besides, in lines 7 and 8, when **Jamal** says,

'*we did like the forecasts of the market*', it could be seen as a goals and plan stage, as an activity that was requested by the assignment and was planned and already accomplished by the group.

Also, in lines 11 through 13, when **Richard** says, '*(…) I feel like there's so much competition in China sorry China is already self-sustained*', it is indicative that although the conversation has been moving towards a goals and plan stage, there is still an occurrence of the task definition phase, which supports the claim that the transition from one phase to the next one is not a linear sequence, given the nature of the vivid interactions that might happen in the context of project meetings. Also, there is an implicit element in the use of the pronoun '*I*', where it gives that what he is expressing is more a fact than a perception.

Furthermore, the next phase of the process, strategy, is starting to show some lights with the use of words such as '*already self-sustained*' in line 13, which could certainly be seen as a way of setting the stage for creating a strategy in relation to what to consider or not, where the conversation is moving towards the following stage, although, keeping a couple of elements that might still need more discussion.

In addition, it has been seen that dialogues vary in thoroughness and depth with which students treat their tasks (e.g., deciding on the market share is surely not the only goal that they have to attain), where the dialogue about goals is broken up across the larger conversation that has been taken place along the project meeting.

In extract 4.3.4, the group have been focused on one of the tasks that the project requires, thus, it has been evident the display of the goals and plans phase:

Extract 4.3.4. Group 3 – 8 minutes into the meeting 2 out 6 – (140619)

Line	Student	Utterance
1	Richard:	yeah that's what I think ((unclear – in
2		overlap))
3	Aaron:	you hear that about obviously **you want to**
4		**base it on a good choice based on the best**
5		**option** ultimately everyone's coming up with
6		that problem you know **people agree on a**
7		**country and then decide you know they read**
8		**one thing that says otherwise**
9	Richard:	well I feel like now worries me it's like
10		((in overlap – not clear what they both
11		say))
12	Aaron:	**you wanna get it right** ((**Richard** says yeah))

Line	Student	Utterance
13		but also ultimately
14	Richard:	whereas you're right I don't know
15	Aaron:	no where's right
16	Richard:	**exactly now I feel like we can stick to our**
17		**Western Australia** or other
18	Aaron:	**we have more than enough good solid argument**
19		((**Richard** says uhm)) so justify it
20	Richard:	**yeah but I don't know it's not too late** she
21		(the lecturer) said ((**Aaron** says it's not to
22		change)) because the fact we've not used
23		anything about capacity or anything **it's**
24		**never too late to change**

In extract 4.3.4, throughout lines 3 and 4, **Aaron** has expressed his position regarding a task that **Richard** has been doing, by saying, '*(…) you want to base it on a good choice based on the best option (…)*', which could be seen as a form of feedback, and also, the use of the pronoun '*you*' is in fact, an implicit '*we*', the team group, pointing out that the aim is to justify their decision based on arguments that are solid so they, as a group, could continue to do another task of the project.

In lines 6 to 8, **Aaron** says, '*(…) people agree on a country and then decide you know they read one thing that says otherwise'*, where the '*you*' perspective is, in reality, an implicit '*we*' perspective, which could be possibly understood as an opinion that might direct what **Richard** wants to define through line 9, '*well I feel like now worries me*', as a plan without going around.

Consequently, Aaron's exchange is later emphasised by himself in line 12, when he says, '*you want get it right*', being a reinforcing feature for achieving a goal, where the '*you*' perspective, in turn, is an implicit '*we*' perspective, and that is somehow strengthened by **Richard** with the explicit use of the '*we*' perspective, in lines 16 and 17, when he says, '*exactly now I feel like we can stick to our Western Australia*', and that is immediately endorsed by **Aaron** with another explicit '*we*' in line 18 saying, '*we have more than enough good solid argument*', giving a justification for what Richard has been doing and somehow, exercising a sort of co-regulation.

These both instances, where Richard and Aaron, across lines 16 and 18, use the pronoun '*we*', are explicit evidence of shared regulation, that is opposed to the implicit and subtle '*you*' that has been used by Aaron in line 3; thus, presenting the complexity of the identification process of co-regulation and shared regulation instances in the

context of team groups, where the occurrence of both phenomena are so entangled, creating a restriction when attempting to split them up.

Furthermore, in line 20 **Richard** says, '*yeah but I don't' know it's not too late she said'*, which could be perceived as a self-reflection about what the lecturer has established as part of the project guidelines, and that somehow, defines and directs the decisions the groups as an entity make, which ultimately, could be identified as an element of co-regulation exercised by the lecturer, where the focus is not on co-regulation but regulation within the team.

Then, in lines 23 and 24, as **Richard** continues his speech, he says, '*it's never too late to change*', emphasizing that his plan could be amended if required. Additionally, this element could also be identified as a strategic element, which will be explained in the following section.

3. Strategies

The strategy phase is defined by Hadwin *et al.* (2018) as the students' engagement, drawing around the tasks upon a variety of tactics to accomplish the goals, where process, progress, and products of each phase are monitored and evaluated so to adapt later any of the stages.

Extract 4.3.5 brings strategic elements that have been identified of this stage:

Extract 4.3.5. Group 3 – 8 minutes into the meeting 2 out 6 – (170519)

Line	Student	Utterance
1	Jamal:	that's **basically says for the past 5** years
2		yeah for the past five years or something
3		China is being nearly 100% self-sufficient
4		in nitric acid
5	Richard:	uhmmm
6	Jamal:	so they actually **have too much**
7	Richard:	yeah it's supposed (unclear, all speaks at
8		the same time)
9	Aaron:	yeah it'll be like the steel thing where
10		they start dumping very cheaply so
11	Richard:	even **America by like 91 there were 65 nitric**
12		**acid plants** and most of them were for
13		fertilisers but them it was all
14	Aaron:	**America is quite big** for nitric though
15	Richard:	**I suppose** (unclear) but it's something that
16		**you'll need to research**
17	Aaron:	OK

The extract 4.3.5 presents elements of task strategy, which have started to be shown as **Jamal** mentions in line 1 a reference connected to the context of the assignment, '*for the past 5 years'*, posing as an approach on how they can start narrowing down the options for their task, location, which is connected to what has been started earlier in the interactions, when in line 13 of excerpt 4.4.3, **Richard** has said, '*China is already self-sustained*'; then, in line 6 this is reinforced by **Jamal**, when he also says '*have too much'*, supporting his contribution.

In lines 11 and 12, **Richard** makes reference to the number of 'plants' when he says, '*by like 91 there were 65 nitric acid plants*', giving specific facts to what is being addressed and so to progress the task, which in line 14 brings **Aaron** to the discussion saying, '*America is quite big*', in a way of supporting what Richard has just mentioned, but with the intervention of **Richard** himself in line 16 replying to Aaron, '*you'll need to research*', suggesting that a stronger argument should be provided so the goal of the task is achieved using solid reasons, where there is an explicit '*you*' perspective use, that is related to a form of co-regulation being applied, which could be claimed to be a strategy but equally a plan for achieving the goal (i.e., via researching), offering an example of the complexity for the allocation process that has been faced while trying to use Hadwin *et al.'s* (2018) work.

Moreover, the earliest points that the group members have been making have been used as way of justification and reason, supporting the decision-making process that the team members have started to build.

As the group interaction continues, later in the dialogue (extract 4.3.6), the elements of strategy are shown in a more straightforward way.

Extract 4.3.6. Group 3 – 14 minutes into the meeting 2 out 6 – (170519)

Line	Student	Utterance
1	Aaron:	America industry right now **is despite**
2		**everything is** actually doing quite well and
3		the important tough I think **I think the good**
4		**thing about the US is the educated workforce**
5		which I think it's quite you know if you **if**
6		**you go somewhere new** you're gonna either **pay**
7		**people a lot of money to come in there** and
8		**train people** and you **start paying to train**
9		**people** and the US infrastructure there **is a**
10		**massive industry**
11	Jamal:	that's what I'm thinking about like one the

Line	Student	Utterance
12		US **it's going to be how easy is to find**
13		**regulations** and **stuff**
14	Richard:	yeah
15	Jamal:	so I see
16	Richard:	but when did she say like for anything
17		outside the EU just use the British or US

At first in extract 4.3.6, **Aaron** is supporting with firm elements of engagement the discussion, which starts in line 1 until 9, displaying a total commitment to the task, bringing features that shows his motivation and reasons for his proposal, mentioning elements such as '*educated workforce*', as a strong aim to what he wants to communicate to his peers; also, as he continues his speech, provides elements that create a concrete strategy to sort out the task.

And in doing so, **Aaron** makes use of '*you*' implicitly (line 6), referring to anyone in the team, but without being direct to any of the team members. It is in this type of interactions, where what CASoRL model (2018) proposes regarding the existence of co-regulation is not suitable to describe it. The use of a '*you*' perspective by Aaron is a more shared regulated instance, implying that what he has been stating needs the participation of the team members, which is reinforced in line 8, again, using '*you*' to address the team implicitly, avoiding directing his speech to anyone in the group. Thus, the dialogue provides evidence of Schoor's (2018) work shortcoming.

Likewise, in line 12 and 13, **Jamal** says, '*it's going to be easy to find*', pointing at whether or not the choice should be made on the basis of how easy it could be to find the information, maintaining a motivational task engagement, being this a common characteristic of the strategy stage as it has been exemplified by Järvelä *et al.* (2016) in their study.

4. Coordination

Coordination has been described as how a group, as a collective entity, organise their own members from a social perspective (Schoor, 2018), in a way that they can engage strategically around the tasks, jointly and agreeably sketching upon a variety of rational, socio-emotional, interactive, and motivational strategies for the successful completion of the assignment or challenge (Hadwin, *et al*., 2018).

The coordination component has been identified along the data corpus in specific cases, for example, when making decisions, having to ask for support from one or another peer, and organising who in the group does what, as part of the activities or tasks development.

Extract 4.3.7 introduces the identification of the coordination phase that has emerged as the team interactions happen in the meeting:

Extract 4.3.7. Group 3 – 8 minutes into the meeting 2 out 60 – (101019)

Line	Student	Utterance
1	Aaron:	**anybody's spoken to Jamal** ((**Fred** says uhm))
2		is Jamal still alive
3	Richard:	I hope so (laughter)
4	Jamal:	oh yeah
5	Aaron:	sending good vibes (unclear – hard to get)
6	Conor:	aye
7	Richard:	does she (referring to the lecturer) say
8		good
9	Aaron:	**so do you care wait to speak to him to like**
10		**think about or going for this** ((**Conor** says
11		uhum)) suppose (unclear) or to think
12		tomorrow today after then (laughter)
13	Richard:	oh yeah (unclear)
14	Conor:	if you're gonna pay for a plant today
15	Richard:	**yeah I'll do it then**
16	Aaron:	you know last minute addition is fair
17	Richard:	nooo I've been meant to be this (world) how
18		this is wrong (unclear)
19	Aaron:	they got your tents and your dos at some
20		point like they just supposed to sign
21		(unclear) the world she added something and
22		you make it and you end it I bet you
23		((**Richard** says yeah)) I bet you I bet you
24		sign both or some you know just like that's
25		all like these

Excerpt 4.3.7 brings an example of this element, where in line 1, **Aaron** says, '*anybody spoken to Jamal*' (who did not attend this group meeting), triggering a series of responses from the group, giving this utterance a sense of need to ask for his input, when deciding about one of the tasks the project requires for its successful completion.

Additionally, it is reinforced by **Aaron** again, when in lines 9 and 12, he asks to the whole group with a subtle '*you*', '*so do you care wait to speak to him to like think about or going for this...*', which is an explicit '*you*', intended to regulate a team's member

behaviour, giving the impression of being asked specifically to someone within the group, but in reality, he is raising a question to everybody; thus, there is a general agreement on the way this action could be agreed.

Conor, in line 14, says, '*if you're gonna pay for a plant today*', which is an implicit use of the pronoun '*you*', addressing the group with a suggestion to do something in a hypothetical scenario, avoiding mentioning or referring to a specific team member. This utterance shows how shared regulation in the context of a group is not always necessarily linked to the use of the '*we*' perspective but that could imply a more complex relationship.

Furthermore, when in line 15, **Richard** says, '*yeah I 'll do it then*', displaying somehow an agreement to do an activity that is related to what the group aim to complete. Although, from line 16 onwards, the conversation seems to be a banter or even off topic, these are the types of elements that help the dialogues be more fluent and keep smooth the dynamics and interactions among team members, being an intrinsic and natural element of the groups, when members might show some form of disengagement, or simply want to share their feelings or personal activities (Hendry, *et al*., 2015).

In excerpt 4.3.8, the group have been deciding on how to allocate some activities that are required for a presentation, that is part of the project activities, and that needs to be completed:

Extract 4.3.8. Group 3 – 13 minutes into the meeting 2 out 60 – (171019)

Line	Student	Utterance
1	Conor:	**so what do we need to do just now**
2	Fred:	**I think that's the only I could do** like like
3		the best use of this time could be just like
4		I think **how we're gonna like cut the source**
5		**for** like the ((**Conor** says for the talk)) for
6		the talk yeah
7	Aaron:	because **the talk**
8		(In overlap – unclear)
9	Conor:	**how we're gonna** I think ((**Richard** says I
10		hope to))
11	Fred:	I think **I think is doable because** I've seen
12		so much of it actually (overlaps)
13	Conor:	yes
14	Richard:	uhm yes
15	Fred:	so I think yeah
16	Conor:	**should we should we do like the** generals so

Line	Student	Utterance
17		like I'll do capital costs someone does
18		environmental ((**Fred** says erm)) like capital
19		costs include the cost of utilities cost of
20	Aaron:	or **what if we broke it** into big sections
21		(In overlap - unclear)
22	Conor:	but if we do that then
23	Fred:	no no like that's for like yeah that's for
24		**we've got that was actually copying her** (the
25		lecturer) thing and **I think it doesn't work**
26		**for a talk** it doesn't work going in that
27		order
28	Richard:	uhm
29	Fred:	**like no way** like I think
30	Conor:	**I think for me the main part is** where how
31		much
32	Fred:	yeah I think **you start off by saying what we**
33		**found** like the world's capacity to be
34		((**Aaron** and **Conor** say yeah)) which which I
35		didn't find anything (laughter) well **I'll**
36		**find like something** I have to

In line 1 of extract 4.3.8, **Conor** raises a question that seems to be directed to the whole group, '*so what do we need to do just now*', using an explicit '*we*' perspective, as a way to prompt the group to organise somehow, what is going to be presented, avoiding pointing out to a specific member for assigning the activities; this is followed by **Fred** in line 2, '*I think that's the only I could do like*', which could be understood as if he had taken a responsibility for a task and had reached a point, where he might need a kind of support from the team.

Furthermore, **Fred** continues his speech immediately in lines 4 to 6 by asking, '*how we're gonna like cut the source for like the for the talk yeah'*, again using an explicit '*we*' perspective, where there is a need to coordinate how the upcoming presentation is going to be delivered, centring the conversation around the speaking to present their project progress so far, which has been the activity that needed to be coordinated among the team members. In line 7, **Aaron** says, '*because the talk*', confirming that what has been the focus of what needed to be organised and the point of discussion.

Moreover, in line 9 **Connor** is posing a question, '*how we're gonna*', being this utterance an explicit '*we*' perspective, that seems to be in line with or retaking what **Fred** has previously said in line 4, bringing him back to the discussion about the task, saying in line 11, '*I think is doable because…*', which seems to create an atmosphere

of agreement among the group, as in the consecutive lines (13-15), the members present in the meeting seem to agree with the statement.

Therefore, **Conor** in line 16 is making a suggestion to the whole group, *'should we should we do like the…*', where there is an explicit use of the '*we*' perspective, which looks for allocating the possible sections that could be presented, strategizing a kind of sketch according to the elements that might need to be discussed in the presentation; but that in turn, it could be somehow seen as a different form of strategy as defined by Hadwin *et al.* (2018), given the granular element of the creation of a product.

As such, what has been said by **Conor** in line 16 is immediately followed by **Aaron** in line 20, '*what if we broke it into big sections*', proposing a direct strategy through the use of an explicit '*we*' to collectively work on that so the deliverable or product could be organised. This suggestion prompts **Conor** and **Fred** to express their disagreement through lines 22 and 23, with **Fred** stating in line 24, '*we've got that was actually copying her…*', again two team members use a '*we*' perspective, implying that what Aaron has said would be similar to the structure that the subject lecturer has established as the content for the report, where **Fred** reinforces his position in lines 25 and 26 by saying, '*I think it doesn't work for a talk*', which is followed by a '*like no way*' in line 29.

Subsequently, in line 30, **Conor** adds to the discussion, '*I think for me the main part is*', trying to, somehow, realign the main point that matters for what needs to be organised. Consequently, in lines 32 and 33, **Fred** suggests by saying, '*you start off by saying what we found*', making use of an implicit '*you*', which can be seen as '*we*' because he then mentions that he '*didn't find something*', structuring the content of the speech to be delivered by themselves – the group, closing his intervention in lines 35 and 36 with, '*I'll find like something…*', committing himself to an activity connected to the product of it.

Extract 4.3.8 offers an example of coordination in the context of teamwork; however, one might also argue it could fit in 'goals and plans' or 'strategies' phases, and here, in this difficulty of identifying these phases clearly, is where the current models fall short.

5. Standard/Adaptation

Standard/Adaptation has been one the most difficult aspects to be identified in the data corpus of this work because it is a phase, where the team as a group drive or make changes at any point of the interactions while dealing with the tasks. This element could also be referred to as how the group, collectively, persist and find a solution to the challenge with reference to the standards required (Miller & Hadwin, 2015).

Additionally, this adaptation could arise on the fly to optimise learning in the actual task, or even include changes to future activities (Hadwin, *et al*., 2018). Miller and Hadwin (2015) have presented an extract, where participants reflect on their role in an assignment, making explicit the need of having better discussions about the tasks, and suggesting a change in the strategy they have used in the past, for a better and more structured one that really serves their interests.

The extract 4.3.9 is a rich instance of adaptation that has been identified in one of the students' meetings:

Extract 4.3.9. Group 3 – 16 minutes into the meeting 2 out 6 – (120919)

Line	Student	Utterance
1	Aaron:	I think just to reproduce that this nitric
2		acid plant basically
3	Richard:	so that we are producing nitric acid for
4	Aaron:	we are producing nitric acid for the
5		explosives industry in Australia
6	Conor:	and I'm sure mining
7	Aaron:	no no no
8	Richard:	mining (laughter) metrics
9	Aaron:	I'm closed and **I hope we're good anyway**
10		**location capacity sir with stuff like that** I
11		think **then you can go and look but** I don't
12		know what we're gonna do if you wanna 'cos I
13		think ((**Fred** says I like that)) with that
14		worth what technology of the actual design
15		of the plant the most important part of this
16		stage **'cos that is the key for the**
17		**presentation**
18	Richard:	**we need to justify why we're not doing it in**
19		the agriculture or in India and China
20	Fred:	oh **I agree I think like the justification of**
21		**the location is just as big as** that thing
22		right now
23	Richard:	yeah **'cos she** (the lecturer) **tried to stress**

Line	Student	Utterance
24		**that point** like she **she said why also why**
25		**you've done this process but why you're not**
26		doing any other process
27	Fred:	yeah
28	Richard:	so I think **to put it like the reasons we're**
29		**doing it in Australia for the mining**
30		**industry is because** the Asian Market is so
31		saturated

In excerpt 4.3.9, **Aaron** in lines 9 and 10 says, '*I'm closed and I hope we're good anyway location capacity sir with stuff like that…*', pointing out that with having that specific information, somehow the group will be sorted according to the project requirements, in terms of the metrics that have been established by the project guidelines. Then, in line 11, he says, *'you can go and look but*', with an implicit '*you*' perspective use, referring to 'us' or 'anyone' in particular, indicating that there is a need to compare what he could have sketched to the presentation requirements.

Moreover, in line 11 utterance there is a vague reference to reflections, where they are manifested as the uncertainty '*I don't know what we're gonna do…*', thus, the team members are trying to recognise where these shortcomings or gaps are, but it is not clearly or explicitly acknowledge that they are adapting as such.

Consequently, **Aaron**, in lines 16 and 17, makes explicit reference to '*the presentation*', which is a technical meeting with the class lecturer, where the group will report their current project status, being a milestone towards the project completion.

Furthermore, **Richard**, in line 18, says, 'w*e need to justify why we're not doing it in…*', which is an explicit use of the '*we*' perspective, as a way of setting a standard that support the decisions they all, as a group, have made for one of the most significant activities, thus, justifying their decision based on what the actual project requires; what Richard has just mentioned seems to resound in **Fred**, as in lines 20 and 21, when he says, '*I agree I think like the justification of the location is just as big as…*', making clearer that the task needs to be based on solid arguments that could satisfy the project guidelines, which ultimate serve as the standards to what the decisions are expected to be compared.

Later, in lines 23 through 25, **Richard** says, '*'cos she tried to stress that point like she she said why also why you've done this process but why you're not doing any other process*', making use of the implicit '*you*', but in reality, he is denoting '*us*', the team group, or 'anyone' in specific; also, here the explicit mention of the lecturer plays a special role, due to that it could be seen as the standard or reference point that might direct the decisions the group are making, causing an adaptation to their internal dynamics and interactions, which could be a reflection of how aligned their approximations are to what in reality is expected, and it can also be seen as an instance of external co-regulation.

Finally, in lines 28 through 31, as **Richard** continues to talk saying, '*to put it like the reasons we're doing it in Australia for the mining industry is because…*', he reinforces his idea through the use of an explicit '*we*' perspective, bringing elements that could possibly be aligned to the task requirements, and also, incorporating what the lecturer has highlighted in previous interactions with the group, which might be seen as a sign that adaptation is happening along. Although, there is a kind of recognition of where the gap is, this is ambiguously admitted that they are still revising it *per se*.

In extract 4.3.10, the group 4 have been discussing about the location for the plant as part of the tasks that the project requires, and it is doing this that the standard/adaptation phase has been identified.

Extract 4.3.10. Group 4 – 12 minutes into the meeting 2 out 6 – (020420)

Line	Student	Utterance
1	Adam:	**we don't have a location** and **we don't have a**
2		capacity
3	Emily:	I've got it
4	Adam:	uhm ok that's fine so ehm
5	Robin:	**how do we know** that those are what we are
6		talking about
7	Adam:	yeah
8	Nick:	as long as **we just kinda not made a decision**
9		as long as **it could be rationale**
10	Emily:	**no cause we are supposed to show something**
11		like that (In overlap – not clear)
12	Adam:	it's something it is to that we are meant to
13		do about the location processing objectives
14		options production routes and a rationale
15		for chemical alternatives plus technology
16		analysis and build a heat implemented
17		network (unclear) and then we do like to
18		choose the sort of

Line	Student	Utterance
19	Emily:	well **I think I've heard and there are ports**
20		from different options and they've got
21		plants in Egypt they've got two in Germany
22		and they've got one in Qatar ehm as long as
23		we can work out the location in Germany so
24		the rest of Europe is something we can start
25		our BFD (block flow diagram) to work out as
26		a location we can't locate/work in China
27		cause of the saturation and stuff like that
28	Nick:	what's the thing going to happen **if we find**
29		**somewhere in Europe or Canada** because we
30		think that is going to happen
31	Emily:	**the fact about Canada** is cause they're
32		producing between 1000 tons per day and 1500
33		tons per day
34	Nick:	okay

In extract 4.3.10, **Adam** starts off the discussion by saying in lines 1 and 2, '*we don't' have a location and we don't have a capacity*', where there is an explicit use of the '*we*' perspective, that immediately brings **Emily** to the scenario by saying in line 2, '*I've got it*', which by some means redirects the conversation to the activities that have led to the conclusion of the task, based on certain parameters. Then, in line 5 **Robin** says, '*how do we know that those are what we are talking about*', making specific emphasis in '*we know*', displaying an explicit form of team shared regulation, setting a reference to how effective is what they, as a group, have accomplished until that point; creating the conditions for the other team members present to speak up and support their ideas and reasons, or even controvert any statement.

Subsequently, in line 8, **Nick** says, '*we just kinda not made a decision*', with an explicit use of the '*we*' perspective, giving a hint that could be seen as a component associated to an adaptation element that is happening on the fly, thus, possibly optimising or adjusting an outcome to what the task entails. Additionally, what is said by **Nick** in line 8 could also be seen as a good example of 'coordination', where students are engaging in strategies for decision-making; the phrase '*we just kind not made a decision*' is fundamental for acknowledging this events, which then in line 9, he himself reinforces by saying, '*it could be rationale*', illustrating his comment.

Nevertheless, **Emily** strongly shows her disagreement by saying in line 10, '*no cause we are supposed to show something'*, again, an explicit '*we*' is seen here, referring to the fact that their proposals are expected to be aligned to what the project guidelines

dictate; in consequence, **Adam,** through lines 12 to 17, starts listing a series of tasks that are related to what is expected to be included as part of the project completion, which could be seen as a way of refocusing the group around the guidelines, looking for a much straightforward decision-making process.

Furthermore, **Emily** states in line 19, '*I've heard and there are…*', that indeed signs post certain reference to information that could function as a standard or idea to develop her proposal, adding more details along lines 22 to 27, with a continuous and explicit use of the '*we*' perspective along her intervention, which is later, in some way, questioned by **Nick,** in lines 28 through 30, asking **Emily,** '*what's the thing going to happen if we find somewhere in Europe or Canada*…', about two possible options for the decision that has been the focus of their exchanges, closing it with '*because we think that is going to happen*', where the use of '*we*' could be meant an '*I*' perspective, given the context of their exchanges. Also, throughout lines 27 to 29, **Nick** is reinforcing that the options for the outcome of their decision might come from those two choices; therefore, in line 31 **Emily** replies, '*the fact about Canada*', which could be understood as a manner to start to draw some form of conclusions and thus, excluding one of the options that Nick has just introduced, leading to a more feasible decision as the meeting continues.

As it has been already discussed, it has been apparent that students' interactions transition from one phase to the subsequent one does not follow a linear sequence, but verbal exchanges could be allocated to a phase that might have been thought to emerge in a later period, happening before, and even segments, where what is said by the students seems to go back to a stage assumed to be over, proving the complexity of the interactions and the intricate nature of the transactions that occur in a group context.

The previously said is exemplified in excerpt 4.3.11, where despite how developed the meeting could be seen, students' interactions fluctuate from one stage to another, and even go back to a previous phase.

Extract 4.3.11. Group 4 – 1 hour and 19 minutes into the meeting 2 out 6 – (020721)

Line	Student	Utterance
1	Grant:	so **I'm doing the ehm like the convergences**
2		of all the technical grades of the ammonia
3		and the nitric acid **then based on our**
4		capacity range

Line	Student	Utterance
5	Nick:	so that means you've been running the model
6		based on the paper
7	Grant:	yeah **I'll be writing something about that**
8		((**Nick** says ah okay so you)) ***I* need to do**
9		the numbers so **I'll look at** the numbers are
10		((**Nick** says okay)) because **I'll I'll use** the
11		numbers to get our basic conversion
12	Nick:	so then **you could discuss** what temperature
13		is
14	Grant:	yeah and then use those numbers to get **our**
15		basic conversion ((**Nick** says so okay)) so as
16		well as maybe try to find more German info
17		for this
18	Nick:	so **are you doing** the material balance as
19		well
20	Grant:	yeah I do
21	Emily:	**do we need to** do the material balance for
22		this stage
23	Robin:	no no
24	Nick:	well **we need to do** a rough one surely for
25		the material consumption
26	Grant:	yeah yeah
27	Adam:	that's one for the kinda **talking about the**
28		**conversions more**
29	Grant:	yeah I'm not gonna lie about that
30	Emily:	I'm actually **I'm also pretty sure if you**
31		**look in that document** it mentions how much
32		to use for that capacity ((**Grant** says yeah
33		and **Adam** says yeah very comparable)) **which**
34		**might just give you** a- and **we need to just**
35		**like bung** another number and it looks like
36		we have given a range ((**Grant** says yeah I
37		like that)) sorry for more
38	Grant:	yeah yeah this could be this could be cases
39		like the conversion will probably be like
40		this plant is like getting a ninety per cent
41		conversion like give me that sort of number
42		for me but I'll be fine
43	Emily:	yeah I think **if we did it** based on at this
44		stage what other people have done instead of
45		all what **we're** talking

In extract 4.3.11, it could be read in line 1 **Grant** saying, '*I'm doing the ehm like the convergences of*', that is a statement linked to one of the project activities that he has been working on when saying, '*I'm doing*', and directly related to a task definition phase stage that he had been started earlier*;* then, in line 3 as Grant

continues to talk, he says, *'based on our (…)*', displaying some form of strategy through lines so to develop what comes next once the task is finished.

In line 5 **Nick** asks Grant, '*so that means you've been running the model (…)*', which could be identified as a kind of coordination stage through enquiries that leads the conversation to **Grant**, who replies in line 7, '*yeah I'll be writing something about that'*, that shows how the strategy he had already started to draw continue to develop, reinforcing it when saying in lines 8 to 12, '*I need to do (…) I'll look at (…) I'll I'll use the numbers to get…*', which are phrases connected to a strategic phase and similar to the examples provided by Järvelä *et al*. (2016), and that is followed through by Nick and Grant until line 16.

Nevertheless, in lines 18 and 19, **Nick** asks a question to Grant, '*so are you doing the material balance as well'*, which moves the conversation back to a task definition setting, that is followed by **Emily** in line 21, when raising the question, '*do we need to do the material balance…',* bringing up the attention of the team members present in the meeting with the use of an explicit '*we*' perspective, to share their concepts regarding the topic, which shows how complex and intertwined the students' interactions could be, associated to the nature of the activities they have been involved in, and the level of engagement they might be displaying.

Through lines 24 to 25, **Nick** says, '*well we need to do the material balance for this stage*', that implies that a form of coordination among the team members is emerging, using an explicit '*we*' perspective, that is followed by a strategic element, when in lines 27 and 28 **Adam** says, '*(…) talking about the conversions more*', which is agreed by **Grant,** in line 29, expressing, '*yeah I'm not gonna lie about that*'.

Subsequently, **Emily** starts to draw a sort of strategy when saying in lines 30 and 31, '*I'm actually I'm also pretty sure if you look in that document (…)'*, which then turns into a sort of standard stage, when through lines 31-32 says, '*that document it mentions how much to use for that capacity*', and supported by **Grant** and **Adam** in-line to what Emily has mentioned saying, '*yeah – yeah very comparable',* and then, reinforced as a standard/adaptation when **Emily** adds in lines 33 and 34, '*which might just give you a- and we need to just like bung another number (…)*', being a strong distinctive attribute linked to this phase with the use of an explicit '*we*' perspective, closing it in lines 35 and 36 with a, '*it looks like we have given a range*', that is a

common adaptation element applied while a reference element is used when solving a task (Miller & Hadwin, 2015).

Furthermore, **Grant** in lines 38 to 42, starts to devise a strategy, '*this could be this (…) the conversion will probably (…) like give me that sort of number for me*…', that encompasses certain elements linked to planning what the outcome of the activities could be, which is seconded by **Emily** as a form of standard, taking as a reference what other groups might have executed, when saying through lines 43-45, '*I think if we did it based on at this stage what other people have done instead of all what we're talking*', where there is an explicit use of the '*we*' perspective, bringing a reflection element that could cause an adaptation of what the team have accomplished so far to adjust it based on others' procedures. Similarly, it could be claimed a form of external co-regulation, not associated to the lecturer but to other teams, where there is a form of 'indirect' co-regulation because the other actors have not oriented directly to the team.

In addition, it could be said that extract 4.3.11 shows the richness and complexity of students' conversations. Also, it presents how the interactions fluctuate from one phase to another, and even goes back to earlier stages. Likewise, it is a proof of how these interactions do not follow a linear sequence, but an entangled series, as the teams undertake the activities.

4.4 The co- and shared-regulated learning scheme in context

The elements proposed in this work have been built based on the data. This has facilitated the identification of the elements, which are connected to the study, and how they have been coded across the data corpus of the transcription. The following excerpts present instances, where the components of the additional elements proposed in this work have been clearly identified.

In excerpt 4.4.1 the perspective component has been displayed as the students' interactions have been happening:

Extract 4.4.1. Group 3 – 38 minutes into the meeting 2 out of 6 – (221119)

Line	Student	Utterance
1	Richard:	-to give a capacity pick a number
2	Aaron:	so was that was that Yara production
3	Richard:	850000 metric tons a year which doesn't seem
4		((**Fred** says of ammonia)) of ammonia yeah but

Line	Student	Utterance
5		that **doesn't seem like a lot when you've got**
6		**companies producing** thousands of tons of
7		nitric acid a day
8	Aaron:	I don't think it's thousands a day like I've
9		heard I've heard hundreds a day but never
10		thousands a day
11	Conor:	I've I've got quite a few thousand tons a
12		day
13	Aaron:	really
14	Richard:	yeah
15	Fred:	yeah a thousand tons is like not what we are
16		looking (unclear) ((**Richard** and **Aaron** say
17		yeah)) but then **you** get some of those like a
18		few that go - are really big
19	Aaron:	'cos if **you** think a company like Yara a
20		company like like Yara just (unclear) 50000
21		it yeah makes Mr Yara if **we make** 50000 a day
22		we're not going to get 365000 tons out and
23		15000 tons but
24	Richard:	exactly

In Extract 4.4.1, students have been into the meeting for about 38 minutes, where at this point of the discussion, the first overarching element of the *Perspective* component, ***you***, has been evidently identified in lines 5 and 6, as **Richard** is making his intervention, '*doesn't seem like a lot when you've got companies producing'*. Richard here gives the impression of referring to someone in the room, but this might be interpreted as an instance where he is addressing a crucial element that needs the attention of the whole group, rather than a single, specific person.

As well, when using the '*you*' element, there is a connection to an implicit stage that as the discussion keeps going, leads the conversation to a series of strategies, part of the *Phase* component, that the students have been going through.

In lines 15 to 17 **Fred** uses both the explicit '*we*' and the implicit '*you'* elements when he says, "*not what **we** are looking... but then **you** get some of those like...*". Here again, the '*we'* refers clearly to the team's activity, while the '*you'* does not refer to any one specific person within the team (which if taken without contextual meaning could be read as an instance of co-regulation). The use of '*you*' serves as a way to express other possibilities the team (*we*) must consider as a collective. In addition, in line 21, **Aaron** makes an explicit use of the perspective element '*we*'.

The subsequent excerpt 4.4.2, **Connor**, in line 1, uses the '*we'* which in this case indicates a very explicit action, that of managing their process:

Extract 4.4.2. Group 3 – 20 minutes into the meeting 2 out of 6 – (131219)

Line	Student	Utterance
1	Conor:	so how **we are managing** our managing our
2		process (In overlap - not clear)
3	Aaron:	no no let's keep the technical process as
4		possible ((**Fred** says OK)) as I've said this
5		our process and this is the reactor **we are**
6		**using this is the** ((**Conor** says OK)) **stuff**
7		**and this then you can say what process**
8		**environment** safety and ethics I'll put down
9		environment
10	Fred:	**you see the one on the right-hand side**
11		((some information on the computer))
12		**(unclear) hands side for today and tomorrow**
13		**commercial risks like** ((**Richard** says
14		commercial risks so)) what **would you** take
15		commercial risks like what do you think that
16		meant 'cos in my understanding was that
17		would be like like if we're gonna invest 500
18		million what's what's the risk of that like
19		if the market is going to crash
20	Conor:	yeah is it commer is it commercial risk not
21		kind of like ehm is it not like the if there
22		like it can go either way like there's
23		obviously a like ((**Richard** says what can go
24		wrong)) **how do you describe it** it's like a
25		it's a it's a risk it's hard to quantify in
26		a sense because if like there's a commercial
27		risk it's it's like I don't know it's like a
28		company starts to produce I don't know what
29		I'm saying (laughter)

In extract 4.4.2 there is a strong action (*strategy*) the team are taking to meet their task goals. In lines 5 to 7, **Aaron** says, "...*we are using this is the* (…) *stuff and this then you can say what process environment*...", presenting an explicit '*we*' and implicit '*you*' combination by using the *'we'* perspective*,* as to referring to the team, and then, changes to the '*you*' but still referring to the group indirectly and without a clear sign that is the case.

Fred in lines 10 to 13 says, "*you see the one on the right-hand side* ((pointing to the computer)) (unclear) *hands side for today and tomorrow commercial risks like ((**Richard** say commercial risks so)) what would you take commercial risks like...*",

where it sees initially the use of '*you'* implicitly again, not referring to one of the team members specifically, but perhaps to the team as one.

Again, in line 14, **Fred** makes use of the '*you'* perspective to ask to no-one in particular but the group as a whole a question, avoiding placing anyone in a difficult situation, or to give anyone a chance to claim more knowledge in the point under discussion. In his attempt to seek clarity on an idea his preferred action is not to direct his question to a specific team member, which could be problematic from the perspective of ensuring all team members maintain equal status (McQuade, *et al*., 2020), but to the collective '*we*' and the team as an entity.

Whereas later, in line 24, **Connor** says, "... *how do you describe it*...", not referring to anyone present or the team as such. Here, he uses the pronoun *you* to raise a question that he has and would like to have answered, potentially posing a challenge to the team in an implicit, rather than an explicit manner.

Additionally, the use of '*you*' instead of '*we*' does not require placing ownership on the team or any of its members, that is, if his query does not get answer, then, an individual or the team might decide to take an action next.

There is a very subtle difference between the two '*you*', the '*you*' singular and the '*you*' plural, For the first one, they are not addressing anyone specifically, while for the latter, they could be addressing everyone at once.

Extract 4.4.3 brings a series of exchanges that the group 4 have been having, mainly revolving around one of the central tasks for the project completion.

Extract 4.4.3. Group 4 – 20 minutes into the meeting 2 out of 6 – (160420)

Line	Student	Utterance
1	Emily:	ehm and there's similar projects already
2		over there there´s places that **we know we**
3		**could consider too** ((**Nick** says yeah))
4		(unclear)
5	Grant:	**but at least** there's one thing **we can like** I
6		guess transportation to France from Germany
7		and then it can serve ((unclear - in
8		overlap))
9	Emily:	to put somewhere near a train track and
10		(unclear) the rest of ehm let's say mainland
11		Europe
12	Nick:	OK **I'd like** to go for Germany
13	Adam:	and how's the market over there

Line	Student	Utterance
14	Emily:	erm the market is pretty good there's a few
15		plants there already **I haven't looked at** the
16		market probably in there then they should
17		have decided to there's a lot of cheaper
18		plants erm like probably in the Middle East
19		erm in Eastern Europe well but **I think we**
20		**should have** quality that **I think** is probably
21		more important
22	Nick:	yeah **I think is more we need to think** about
23		it **we don't want** to lose money
24	Grant:	well I was thinking that the price of
25		ammonia has spiked up it's like about
26		$5500/ton up to 200000/ton **so like you know**
27		**that happens** repeatedly then basically **we**
28		**are unable to run** the plant
29	Emily:	so **are we saying like** Germany France ((**Grant**
30		and **Nick** say yeah)) yeah OK I've really
31		thought about Germany but **I was not sure**
32		**about** Germany cause that's the matter

In excerpt 4.4.3, in lines 1 through 4, **Emily** makes a specific claim by saying, '*there's similar projects already over there there's places that we know we could consider too'*, which could be related to the fact that she has been researching independently about possible places, where whether or not the group could propose a location for the plant; this statement is then reinforced by the occurrence of a double explicit '*we*' in '*we know we could consider',* which is a distinctive and undoubtedly shared-regulated event, common when a team member wants to bring the attention of the group to focus on an aspect that might be relevant to the goal that is pursued.

Then in line 5, **Grant** says, '*but at least there's one thing we can like…*', which somehow follows the shared-regulated event that Emily has just initiated, using an explicit '*we*' that seeks to keep the accountability on the whole group, rather than put it on a specific member, as the task seems to need the participation of the members present in the meeting.

As the interactions keeps happening, **Adam** poses a question in line 13, '*and how's the market over there'*, which **Emily** answers bringing up information that she has previously read about it, with a specific element that connects with a self-monitory event in line 15, '*I haven't looked at the*…', that is particularly displayed when someone, who has been undertaking an activity still has some pending tasks that required to be completed beforehand (Zimmerman, 1995).

Consequently, in lines 19 and 20, **Emily** reinforces her point of view when saying, '*I think we should have quality*', using a subtle '*I think*' that could be understood as what she is going to see might be perceived by the group as a suggestion than an imposition, which is followed by an explicit '*we*' in '*we should have...*', immediately accompanied by a '*I think…*', where the use of both pronouns plays a distinctive role, when a member of a group is trying to direct the group decision towards a particular option, which is an example of co-regulation happening in a group context.

Nick, in line 22, uses a combination of pronouns again, '*I think is more we need to think*', which could be interpreted as paraphrasing, or even recapping what Emily has said before, and that has regulated implicitly the group dynamic as he adds in line 23, '*we don't want to lose money*', adding a relevant factor that directly affects the matter that has been in discussion.

Further down, **Grant** says in lines 26 and 27, 'so like *you know that happens*', where the use of that '*you*' is an implicit way for presenting his idea, that is not direct to anyone in particular but to all members, being a specific way of addressing them, where this implicit manner of speaking to others and the team has an inherent influence as co-regulation. As a result, **Grant,** in lines 27 and 28, could justify his '*we are unable to run…*', in a collective manner due to the nature or impact that his proposal could have over the project.

Subsequently, **Emily** asks in line 29, '*so are we saying like…*', implying that is a decision that the group explicitly share, and that she then reflects upon in lines 31 and 32, when saying, '*I was not sure about*', which could be connected to the fact that Grant and Nick have already answered to her question while she was talking.

The following section will present the discussion around the implicit and explicit elements, core to the research of the work that has been done across the study presented in this thesis.

4.5 The implicit and explicit elements component

Järvelä and Hadwin's (2013) work has proposed the existence of the perspectives of '*I, you,* and *we*' to point out directly to self-, co-, and shared regulation in the learning context, respectively, which have been broaden by Schoor's (2018) work; however, it has been found out along the research, that the occurrence of those

types of regulations is not strictly true; thus, further details are provided below to explain this.

Based on the data corpus considered in this study, certain students' interactions have suggested a further relevant distinction between two elements, in which some conversational moves by participants explicitly make the required point, whereas other conversational moves do so implicitly.

A frequently occurring pair of examples is the explicit use of the collective pronoun '*we*', as in '*are we going to say how much spending we are planning*', as opposed to the more implicit generic use of '*you*', as in '*you have to have to a sort of contingency capital*', both are intended to encourage collective actions or collective decisions, but one is much more explicit than the other.

Similarly, the pronoun '*you*' sometimes does not refer to a specific group member but to a generic '*you*' outside the team as in the example above. This highlights the ambiguity of '*you*' – sometimes it constitutes an address to a specific person (a matter of perspective) and sometimes, it is an implicit generic term meaning '*one*' or '*we*', the entire group, or '*one*' (as in '*you have to laugh*...' where '*you*' means '*one*/*anybody*').

These two pieces play a vital role, specifically, due to the difficulty faced when behaviours, which are displayed by the students and connected to a regulatory or autonomous stage, are not easily allocated under the scheme proposed by Schoor (2018), and considered initially in this work. Schoor (2018) proposes that perspectives of self-, co-, and shared regulation can be identified through the use of the '*I*', '*you*' or '*we*' pronouns respectively, indicating the perspective that the student takes. However, the ambiguity that the meanings these pronouns have within conversational elements might refer to shared regulation, even when the pronoun itself could have indicated an individual perspective of co-regulation (i.e., '*you'*).

Furthermore, Schoor's (2018) model is meant to be applied in a cascade way; first, with the identification of the overarching phases – auxiliary level, that the students could be working within as the discussions take place; later, the allocation of the OPES components – principal level; and finally, making the distinction among the '*I, you, and we*' perspective to clarify if the conversation refers to 'self-', 'co-' or 'shared regulation' action; aspects that have been exemplified in extracts 4.1.1 and 4.1.2. Another significant aspect is the fact that although analytically this is possible, all

these elements certainly interconnect among themselves, making it difficult to discretise the stages of proposed regulatory cycles.

Figure 4.3 introduces the addition of a new component to the research model, *Elements*, constituted by the implicit and explicit elements, which have been identified through this research work, and that has been made evident across the data corpus.

Additionally, the implicit and explicit elements component has exhibited the intricate processes faced when trying to use predefined models available in the literature, where they are referred as representations and simplifications of the learning phenomena, but that in reality are missing out the complexity of the processes that occur in the learning context; hence, although their relevance and significance, predefined models, such as the ones proposed by Järvelä and Hadwin (2013) and Schoor (2018), were neither appropriate nor a hundred per cent applicable to a students' teams interactions study in the context of a project-based learning framework.

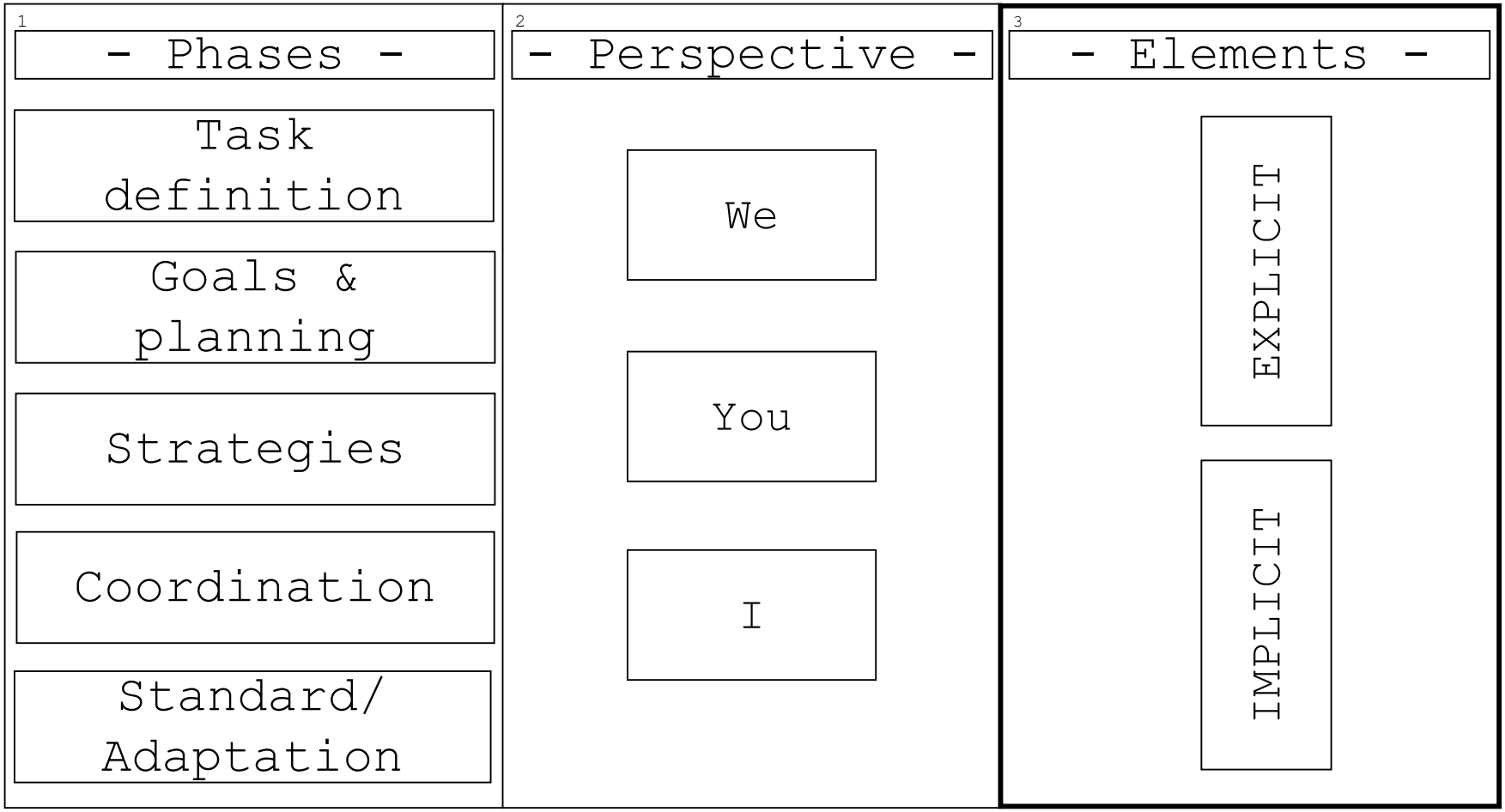


Figure 4.3. The self-, co-, and shared-regulated learning scheme from Schoor (2018) (Phases and Perspective) and Elements as result of the research presented here

4.6 Summary

This chapter has discussed the exhaustive exploratory stage that has taken place, while attempting to apply CASoRL model approach, within the constraints that it has posed, following its structure and instructions as proposed by Schoor's (2018) work, encountering a series of limitations for its straightforward application to the data corpus of this research.

As a result, the chapter has introduced the conception of a modified coding scheme that has been grounded on the research executed by Zimmerman (1995; 1998; 2008), Järvelä, and Hadwin (2013), and Schoor (2018), presenting it as an analysis of actual dialogue data that has revealed inadequacies in previously-published coding schemes, where this research proposed-modified coding scheme is in better position than the previous ones to capture the complexities of real group dialogues settings.

Consequently, it has demonstrated that the phases that the teams go through while attempting and completing a concept-project assignment as they has been described by Järvelä and Hadwin (2013), are not clearly displayed, posing a challenge to the categorisation of students' transactions and interactions to draw a clear line, that signs post that specific instances are completely related to only one phase of the process, when the data have shown otherwise, more than one phase could be identified in an intervention.

Furthermore, the chapter has shown and provided arguments to illustrate, how the identification of the implicit and explicit elements is directly connected to shared regulation in the context of teamwork, offering a classification for the exchanges occurring in a project group scenery for the shared regulation research of teamwork; witnessing, how it is necessary to provide a different conceptualisation for the social shared regulated learning, that acknowledges the complexity and ambiguity that the use of the *'we* and *you*' pronouns poses, and that ultimately can indicate a different form of regulation, that is directly associated to the context where they are used, and what the real message of them is when applied in a teamwork setting.

The subsequent chapter (**5**) will describe the work and analyses that have been made for the conceptualisation and proposal of a model, that serves as the principal framework for the description of the interactions happening in the development of a concept-project assignment in teamwork environment.

5. Shared regulation in teams

In this chapter a comprehensive analysis for the conceptualisation of the shared-regulated model that has emerged as a result of the data analysis is presented. It brings the analytic approaches that were taken for the model conception, initially led to the identification on a priori grounds of two prevalent overarching or main themes, *Knowledge* and *Processes*, common to the students' interactions across the data corpus. A definition for each identified theme will be given, thus, establishing a common rationale for the discussions and analyses that have taken place across the data sessions and meetings held.

5.1 An approach for the definition of a shared-regulated learning themes model

The conception of a model, that almost fully satisfies the requirements of this research, has been one of the most challenging stages when trying to comprehend the data corpus. Braun and Clarke (2013) have stated that the analysis of the data, certainly starts once the transcription phase has been completed. Hence, this assertion has been experienced when trying to conceptualise at first, common and repetitive elements along the data, which have ended up being themes, defined by Miles *et al.* (2014) in Cohen *et al.* (2011), and Braun and Clarke (2013), as the frequency of occurrences, showing reasonable patterns, and being able to group them into categories, types, behaviours, and actions.

Initially, it was looked at pre-existing coding schemes finding them to be inadequate for describing the interactions and transactions that had been witnessed in the data; subsequently, it was needed to devise a bottom-up scheme to help capture what was seeing in real dialogues. Therefore, the components of the model are a direct reflection on the needs of the study rather than a pre-conceptual scheme that did not fit into the data, driven by the sometimes-messy contents of real dialogues. Yet, the studies conducted by Zimmerman (2008), Järvellä *et al.* (2013), Hadwin *et al.* (2018),

and Schoor (2018) have influenced the conception in the early phases. As a result, the research model incorporates features that those researchers have studied.

As it was introduced in **Chapter 3**, Thematic Analysis has been a method extensively used in this research, helping in the conceptualisation of the research model. The research model is made up of two main themes that have been called *Knowledge* and *Processes*, and that have served to group seven themes, which have been proposed based on the type of interactions and transactions that have taken place while the students undertake their project activities; hence, the themes have been classed under either one of the main themes or another, and even, both.

Referring to Thematic Analysis, there are two manners that have, undoubtedly, been used to approach the data, inductive and deductive, which have been already covered in the coding section. Furthermore, while using Thematic Analysis along this research, it was noticed that an element connected to the active role of the researchers' knowledge generation was missed, codes and themes are labels and concepts that researchers assign to qualitative data to identify and organise recurring ideas and patterns. These labels and concepts reflect the researcher's interpretation of the data corpus, and they help the researcher to make up sense of the data and to draw conclusions from it (Byrne, 2021).

5.2 A model of shared regulation of teamwork

Derived from the analyses of the data in this work, the conceptualisation of a research model for the shared regulation of learning in the context teamwork has been proposed. A research model that could explain in much finer detail the complexity of the students' interactions, their vivid conversations, and the learning phenomena that have been seen along their project meetings. The sections below will present the research model and its components.

5.2.1 The main themes

During the data sessions as the data have been deeply explored, discussed, and analysed, a specific feature has been acknowledged, students' interactions could be grouped under an umbrella term made of two main themes, which have been classed as *Knowledge* and *Processes*. These two main categories occur

simultaneously and in parallel while the groups have been working through the project, and they are also interdepended.

For instance, knowledge and processes here refer to group processes, certainly connected to the activities that supported the project progression, level of comprehension of what it was required for the project development, and what information about the assignment was shared and needed to be researched among the team members in the meetings.

Also, knowledge construction in a group setting is usually the reflect of individual's underlying resources, experiences, or even predispositions to perform in certain ways, which is directly connected to what an individual has actually completed (i.e., previous research, solution of problems, and tutorials related to the topic), or what processes they are likely to apply (i.e., find new resources, ask for help of someone probably more knowledgeable, and apply new learning strategies) for the completion of an activity or task, which would ultimately lead to an effective working group (Morgeson, *et al*., 2005). As a consequence, the interception of these two components, *knowledge* and *processes*, is a natural and intrinsic process that occurs as the students' interactions take place across the meetings.

1. Knowledge

Knowledge is one of the main themes that has been identified across the data corpus, under which the proposed themes have been allocated; hence, knowledge could be referred as the information, facts, and abilities that human beings acquired through experience or education (Cohen, *et al*., 2011).

2. Processes

The other main theme that has been recognise in the data corpus is processes, where the interactions, transactions, and other group processes could be considered. Processes could be defined as a series of actions or steps taken to achieve a particular goal (DiDonato, 2013), which are strongly present along the students' meetings, specifically, when tackling and facing the activities for the project completion.

5.2.2 Themes for shared-regulated learning

Once an in-depth familiarisation with the data, and after having initially used Qualitative Content Analysis but figuring out that this method was not the most suitable, as it has been explained in the qualitative methods section, given the richness and complexity of the data, the needs of the research, and in addition, having also carried out some explorations through Discourse Analysis, with not much success; as a result, Thematic Analysis was then considered, providing a good framework, closer to what the study was requiring, and more appropriate for the data that have been collected.

Turning now to the themes, following a rigorous and methodical familiarisation with the data corpus and an iterative refinement, the analyses of the data have helped identify common topics or themes across the different students' project meetings, where certain elements along the students' interactions started to emerge from the data excerpts, with some of them being more prominent than others, and somehow, repetitive along students' meetings, which have allowed the clustering process of the students' exchanges under shared elements linked to the project activities.

As the intensive and extensive data analysis took place along the data sessions, specific themes, understood as patterned meaning across a dataset that represent the interactions while keeping close to the data (Braun & Clarke, 2013). Therefore, seven themes have been identified in the data corpus, which are described as follows:

1. ***Knowledge Sharing (KS)***, this theme is meant to be the moment when students share their conceptual knowledge about a topic.
2. ***Coordination Construction (CC)*** denotes the instant when students after sharing their ideas, building up knowledge to a point of agreement, where coordination means that more than one person is being involved in the process.
3. ***Agreed Common Knowledge (ACK)*** referred as the moment when students reach a mutual understanding after having shared and discussed a topic, task, or any other activity. It can also refer to points where decisions are made.
4. ***Strategy Device (SD)*** outlined as how the students plan a set of tactics or strategies to complete the assignment. Due to the complexity of this themes, it has been assigned with two sub-themes:

a) *strategy device towards the content (SDC)*, which refers to approaches the team takes to address issues of content – e.g., what equation to use in solving a technical problem; and,
b) *strategy device towards the task (SDT)*, defined as the approaches the team takes to progress the task and meet the goals either immediate or overall.

5. ***Inquiry (INQ)***, this theme usually happens when a concept or process is not clear, or when someone is explaining a point but for any reason needs extra clarification.
6. ***Group Operation (GO)*** defined as how the students agree to manage the group and the roles that each member assumes as the project development takes place.
7. ***Referencing (REF)***, this theme is related to the elements (books, websites, other, tutor, peers) that students use as a source of information, explanation, or clarification.

Additionally, there was a theme referred to reflexivity, which due to the constraints of the research itself, there was not much on but when at a couple of points, the students were orienting to considering how they have changed strategies or so when tackling the project tasks.

Figure 5.1 is a pictorial representation of the proposed conceptual model that offers a better perspective for the themes and their relationships. In the figure two circles intercept, representing the main themes; being one of them, the green on the left-hand side, *knowledge*, and the other blue one on the right-hand side, *processes*; both circles are grouping the seven themes that have been identified in the data corpus.

Furthermore, located on the bottom left-hand side, a convention table collates the name of the themes, their corresponding symbols, and the codes that have been assigned to each of them.

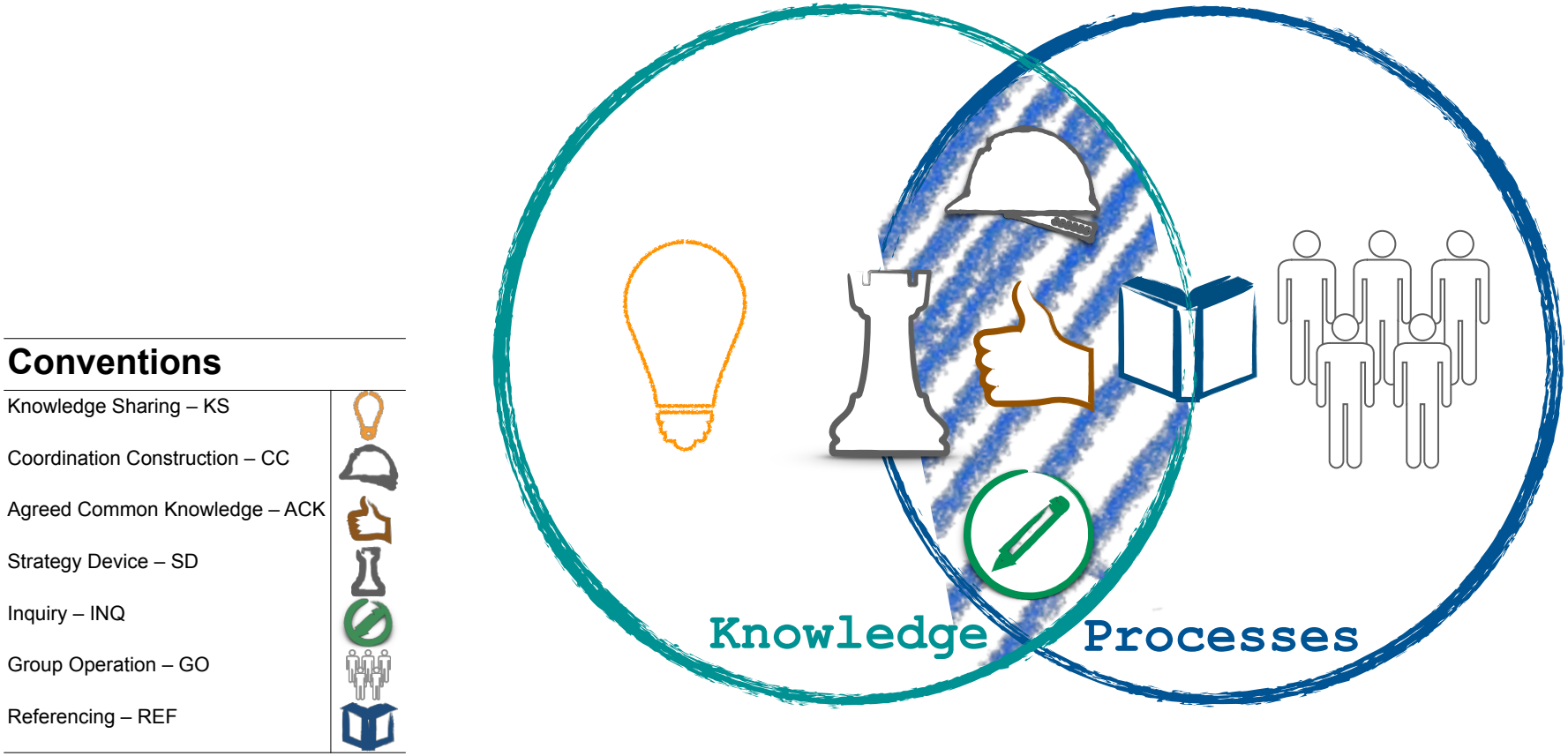


Figure 5.1. Main themes and themes for the shared-regulated learning model proposed in this work

Besides, in figure 5.1 can be seen some sort of overlapping between the two main themes, thus, the themes that have been accordingly allocated, could end up belonging to one of them, or even both at the same time; this phenomenon is primarily due to the nature of the data, as for some themes is almost impossible to draw a line that explicitly say that they exclusively fit in one of the main themes or another.

Furthermore, icons have been matched to each theme, including the conventions that have been used during the data sessions and analyses. All the elements that make up the model will be further explained and expanded in the subsequent sections.

Additionally, during the data sessions and analyses for identification purposes, each theme has been assigned a convention code, equivalent to the first letters of each of them, which have helped mark up within the excerpts the utterances and conversational sequences that have been identified as particular to each of them, thus, facilitating their recognition. Plus, codes have been added to each theme, next to each theme heading in the subsequent sections.

1) Knowledge Sharing – KS

Knowledge sharing represents an instance where students share their own understanding and information about concepts or content about a topic. This theme has been conceptualised under the knowledge overarching theme.

In the following excerpt (5.2.1), the group of students are to have their first video recorded team meeting, where at the beginning of the session some of the members have been talking about topics not related to the project itself as yet, but that could be seen as essential for keeping the dynamic and smooth interactions of the groups; as the members start to arrive and join the meeting, one of the participants kicks start the meeting.

Extract 5.2.1. Group 3 – 9 minutes into the meeting 1 out of 6 – (180820)

Line	Student	Utterance	Theme
1 2	Conor:	hey man you should sell it if you put that on Google (Making fun)	
3 4	Jamal:	(laughter) six grands for these (laughter)	
5 6 7 8	Aaron:	right **site location so are we completely ruling out Europe** can help to construct that are we completely ((**Jamal** says I think)) but UK start	**INQ**

Line	Student	Utterance	Theme
9 10		in the UK but are we completely ruling out the UK	
11	Jamal:	UK has to adhere to Europe EU rules	**KS**
12	Aaron:	okay so that's basic	
13 14 15 16 17 18	Jamal:	so it's Europe essentially and erm like **restrictions on nitric acid's** **fertilizers are becoming more and** **more strict so** ((**Aaron** says OK)) so erm **that's why people companies are** **moving out of the EU** because of that	
19 20	Aaron:	so we'll justify why we are not doing it in the EU	**CC**
21	Fred:	yeah	
22 23 24 25	Jamal:	and the same argument holds for the US actually that's one of the arguments against the US it is like again stringent erm	**KS**
26 27	Aaron:	for fertilizer but for (unclear) could be quite big	
28	Richard:	big (unclear)	

In extract 5.2.1, in lines 1-2, **Conor** is making fun about an activity that Richard has been doing for while waiting alone for the rest of the team members to arrive at the room. Then in lines 5 through 10, **Aaron** raises a question, '*right site location so are we completely ruling out Europe*', which has been classified as inquiry, theme that is going to be discussed later in this chapter, that somehow invites and brings the team up to share their ideas related to one of the most important tasks for the project completion; hence, **Jamal** in line 11 says, '*UK has to adhere to Europe EU rules'*, which could be seen as a form of knowledge sharing, citing a fact in regard to what Aaron has immediately said; in doing so, **Aaron** replies back in line 12, cutting Jamal's intervention, saying, '*okay so that's basic*', which could be seen as a form of agreement.

Consequently, **Jamal**, in lines 13 through 18 continues to present his ideas, **'***so it's Europe essentially and erm like restrictions on nitric acid's fertilizers are becoming more and more strict so*', which brings information that might be seen as an indicative that he has been researching about it previously to the meeting, and that has pointed out to the identification of knowledge sharing occurrence in the context. Although, while Jamal is still introducing his ideas, **Aaron** briefly interrupts him in line 16 saying, '*okay*', possibly indicating that he is following what Jamal has been saying, but this

intervention does not stop Jamal to continue to share more information, further adding, '*so erm that's why people companies are moving out of the EU'*, which firmly supports that this utterance is an indicator of some form of knowledge sharing.

Aaron, in lines 19 and 20, expresses an idea that is indicating coordination construction theme, that will be explained later in this chapter. Connected to his familiarity, **Jamal** adds a comparison statement that is still associated to his idea, when saying, '*and the same argument holds for the US (...) arguments against the US it is like again stringent',* introducing a new location that he has researched and known about it, and specifically, when using the phrase '*the same argument holds'*, which could be perceived as a solid understanding of the limitations and constraints, when deciding about the available options.

Extract 5.2.2 presents the interactions of group 4, where the team members have had a series of vivid exchanges as the meeting progresses, which in the majority of the time are activities related to the project presentation preparation.

Extract 5.2.2. Group 4 – 43 minutes into the meeting 2 out of 6 – (150420)

Line	Student	Utterance	Theme
1 2 3 4 5 6	Adam:	see **there are some references** for the nitric acid one and if you can find it in the reference **books** (Grant coughs – unclear) for producing in batches or compressors and everything else	**REF** **KS**
7	Emily:	okay	
8	Nick:	okay	
9	Adam:	(unclear)	
10 11 12	Nick:	'cos I think **we need to get the way of producing ammonia or how much we're going to be charged**	**KS**
13 14	Emily:	yeah cause every plant **every plant is gonna have**	
15	Nick:	**we can get** the other one	
16	Emily:	every plant is gonna **have a supplier**	
17 18 19 20 21 22 23	Nick:	um-hum I thought about it and they are 'cos **the only thing we're supposed to determine** 'cos it's a bit difficult and **'cos the only thing we can do is like to have chemical plant** and that's like a small volume that **you can buy anything else** I mean is	
24	Emily:	do we really need	**INQ**
25	Nick:	I guess so	

In extract 5.2.2, in lines 1 to 3, **Adam** says, '*see there are some references for the nitric acid one and if you can find it in the reference books*', which is an element that has been labelled as referencing, theme that will be discussed later in this document, where there is a use of supporting elements that could help solve the tasks, in this case books, being a common element across the students' interactions; then in line 4 to 6, Adam says, '*for producing in batches or compressors and everything else*', where there is an undoubtedly element of information that he is sharing with the team, showing that probably he has done some reading or at least, knows what information might be in the references he has just mentioned.

Then, in lines 10 through 12, **Nick** says, '*'cos I think we need to get the way of producing ammonia or how much we're going to be charged*', sharing information with the group that seems to be relevant, or even, reminding them some tasks that the team as a whole need to work out, design the way to generate a product and the cost that might be associated to it. Thus, **Emily**, in lines 13 and 14, adds to the conversation, '*yeah cause every plant every plant is gonna have'*, that although is yet to be a clear idea, she is somehow trying to follow up what Nick has just mentioned.

Next, in line 15, **Nicks** says, '*we can get the other one*', instance that seems to complement what he has said in lines 10 to 12, adding more details to his point, which is instantly followed by Emily saying in line 16, '*every plant is gonna have a supplier*', closing her idea, sharing factual information that supports her statement.

Furthermore, across lines 17 to 19, **Nick** adds '*um-hum I thought about it and they are 'cos the only thing we're supposed to determine 'cos it's a bit difficult*', where he continues to share information related to the tasks that need to be done as part of the presentation requirements, and also sharing with the team his perception of them when saying, '*it's bit difficult*'; likewise, in lines 20 and 21, he says, '*'cos the only thing we can do is like to have chemical plant*', sharing one of the tasks that the project requires of its completion; finally, in lines 22 and 23 he adds, '*you can buy anything else*', aspect that could be seen as resource the group could use to support their decisions, which is somehow challenged by **Emily** in line 24 by asking, '*do we really need*', evidencing that she has been following thoughtfully the information that Nick has been sharing, where in line 25 **Nick** replies, '*I guess so*', exhibiting the intricate nature of the exchanges that the group members have been having, and the challenges that the project completion has posed.

2) Coordination Construction – CC

This theme denotes the moment when students, typically, after sharing their ideas build up knowledge to a point of agreement, where coordination involves more than one person.

In excerpt 5.2.3, as the project meeting has continued to be held, the students have kept going on the dialogues, discussing a suitable location for the plant and the capacity for the it, providing reasons for their decisions.

Extract 5.2.3. Group 3 – 18 minutes into the meeting 2 out of 6 – (250320)

Line	Student	Utterance	Theme
1 2 3 4 5	Fred:	**we could say Australia** and then **we could like say more specifically what we're looking at** ((**Richard** says yeah)) this Western Australia like a region	**CC**
6	Conor:	yeah	
7 8 9 10 11	Richard:	yeah because I think what she (the lecturer) meant is like **if we choose** China and in your technical proposal all **you need to say** is for doing it in China **then you don't** need to	**REF** **CC**
12 13 14 15 16 17 18 19 20 21 22	Aaron:	**we say in Western Australia 'cos it's such a big thing so different so different different places again is only the first stage but for this is something we lack anyway** (unclear) location this is our location justify market /slash/ products so **if we've chosen explosives I think to say we've done explosives** in Australia this is why put the links as much as anything **we need for** the location	
23	Fred:	yeah	
24 25 26 27 28 29 30 31 32 33 34 35 36	Aaron:	that's fair enough ((**Richard** says yeah that's what also I think)) I think because it's such a big thing a bit is she thinks about the capacity is something **we have to say** again ((**Richard** says she says this much)) it's gonna come with (unclear) **again this this is our capacity this is why we can do this capacity /slash/ why we chose to do this capacity based on what's supposed to be or I suppose** I don't know whether Yara think is possible but it could I suppose I	

Line	Student	Utterance	Theme
37		don't know	

Extract 5.2.3 is a neat example of the coordination construction theme occurrence, when across lines 1 to 5, **Fred** says, '*we could say Australia and then we could like say more specifically what we're looking at*', where he is trying to sketch a way to present one place that the group have considered as possible location for the plant that the project assignment requests, trying to direct the group towards a common point so to speak; aspect that could be seen with the continuous use of the '*we*' pronoun, given a sense of unity to what he is proposing; aspect that seems to be followed by **Richard**, who says, '*yeah*', in line 4, and so does **Conor** in line 6.

Then, in lines 7 and 8 **Richard** says, '*yeah because I think what she meant*', making specific reference to the indications or probably feedback that the lecture has given to the group, adding in lines 8 and 9, '*if we choose China*', with an inclination to move the group decision making to somehow organise a strategic sequence, where he has started with the '*we'* pronoun, and then, switched it to '*you need to say (…) then you don't*', given the impression that the '*you'* pronoun implies that is a group decision that needs to be agreed among the members.

Moreover, when in lines 12-15 **Aaron** says, '*we say in Western Australia 'cos it's such a big thing so different so different different places again is only the first stage'*, which contains elements of information that he has probably read or researched about, and that could be useful for the task the team have been tackling, where he is following up what Richard has previously said, aiming to build some sort of consensus around the group, specifically again, with the use of '*we*' pronoun, implying that the team members need to be involved in what he is saying, applying some form of shared regulation.

Also, there is an element of reflection, when in lines 15 and 16, **Aaron** says, '*but for this is something we lack anyway'*, is evident in this utterance, where he explicitly uses the word '***lack*'** to indicate some sort of evaluation of the work this far accomplished by the team, acknowledging that there may be more investigation needed to propose a solution for this specific project requirement. Not only he assesses the work but he also adds more elements to support his point by saying in lines 18 to 20, '*if we've chosen explosives I think to say we've done explosives in Australia this is why put the*

links as much as anything we need', exhibiting elements directly associated to a strong coordination construction, keeping the explicit use of the '*we'* pronoun, implying the need of the involvement of the team members in what he is presenting to them.

Additionally, **Aaron** has had an exchange of ideas with **Richard** specifically, in lines 30 to 34 when posing potential statements saying, *'(…) again this this is our capacity this is why we can do this capacity slash why we chose to do this capacity based on what's supposed to be or I suppose (…)*', that could be a way of putting together the elements they have discussed and looking to build consensus within the group. By adding more points to what has already been said earlier, **Aaron** tries to build up knowledge that might lead to a more task-oriented scenario inside the group.

In excerpt 5.2.4, the group have been discussing some activities that are required for the project; as such, discussion is the basis for coordination construction, and it is through discussion that the group constructs coordination.

Extract 5.2.4. Group 4 – 43 minutes into the meeting 2 out of 6 – (150520)

Line	Student	Utterance	Theme
1 2 3 4 5 6	Nick:	one thing **we haven't gone through** ehm sorry one thing **we definitely have to do** well for everything I suppose it's where do we find our data for talking about the location we can download the data	CC
7	Liam:	we can match all the variables	
8 9	Nick:	are you sure of that I don't see I don't see like	
10	Liam:	a lot of people are doing the same	
11 12 13	Nick:	yeah yeah and then you go and get the same parameters (laughter) if you can see Sigma Aldrich	
14	Grant:	(unclear)	
15 16 17	Nick:	I don't see it in Google I mean that's what I don't understand I don't understand where	
18 19	Adam:	where we're going to get the definitions	
20 21	Nick:	yeah where we're going to get everything else	
22	Emily:	**I'm OK looking** for that	
23 24 25 26 27	Grant:	yeah that would be the case of like the terminal so and **we think they're really obvious like** the capital costing equipment data I asked for something and probably we learn about	

Line	Student	Utterance	Theme
28		how to do that cause that the other	
29		thing I think that's the right thing	
30		to say that like the capital costs or	
31		in the light to like find it	

Extract 5.2.4, bring a series of exchanges the group have been having, related to a presentation that is required to be delivered as part of the project activities. Through lines 1 to 6, **Nick** is bringing the attention of the group when saying, '*one thing we haven't gone through*', where the use of '*we haven't*' could be seen as a statement that implies that an activity needs to be coordinated among the team members, which is straightaway emphasized as he said, '*we definitely have to do well everything (…) for talking about the location*', posing the need that the task he is mentioning is key for what the team intend to develop; thus, certain tasks need to be coordinated and then, agreed around the team.

In the subsequent lines of the excerpt, a series of inquiries are raised that are showing how the group, thorough the use of some strategic elements such as referencing what other groups are doing, for example, when in line 10 **Liam** says, '*a lot of people are doing the same*', which is seconded in a humoristic way by **Nick** in lines 11 and 12, '*yeah yeah and then you go and get the same parameters*', being this an element that could be perceived as a way to ease the group dynamics. Then, in line 22, **Emily** says, '*I'm looking for that*', that is showing how coordination around the task is still happening among the group.

Grant in lines 23 through 31 is bringing information that is setting the ground for the group to coordinate some activities, when saying, '*we think they're really obvious like the capital costing equipment data*', which then turns into direct coordination when saying, *'I asked for something and probably we learn about how to do that (…)*', focusing on '*we learn*' as a particular statement that can be comprehended as a movement to organised the group around a task that could yield a benefit towards the project structure and its construction, implying that obviously, the team members would be involved in.

3) Agreed Common Knowledge – ACK

Agreed Common Knowledge refers to the point when students reach a mutual understanding typically after having shared and discussed a topic, task, or any other activity. Usually, this follows coordination construction, but also, this theme has been identified in students' conversations when some sorts of agreements have been achieved as part of the effort regulation in teamwork, linked to Strategy Device Task/Goal that will be explored later.

Excerpt 5.2.5 is an example of the occurrence of the agreed common knowledge theme, where the team member after having shared their knowledge about the project requirements and discussed their point are moving to an agreement setting:

Extract 5.2.5. Group 3 – 17 minutes into the meeting 2 out of 6 – (250320)

Line	Student	Utterance	Theme
1 2 3 4	Richard:	so I think to put it like the reasons we're doing it in Australia for the mining industry is because the Asian Market is so saturated	
5 6 7 8 9 10 11 12	Aaron:	so you want you want to stay more certain have six percent is like the justification is just like top up the this is our location justification underneath just really play by we've done this and this is why we've done it this is our reactor then that's why we have done it	
13 14	Fred:	aye I think that's quite a good way to do it	
15	Aaron:	this this is what we've done it	
16 17 18	Richard:	'cos that's exactly what she'd (the lecturer) ask it for this doesn't have to be so	
19 20 21	Aaron:	so that's why we need to decide on what the important things that we need to justify	
22 23 24 25	Richard:	yeah ((**Aaron** says that's talk so)) yeah that's the whole points she'll (referring to the lecturer) try to get across	
26 27	Aaron:	**so the location is definitely one of them**	**ACK**
28	Richard:	**yeah**	
29 30 31	Aaron:	this is our location the reason I know she (the lecturer) said that's only done we need to know the country	

Line	Student	Utterance	Theme
32 33 34 35		we don't need the location ((**Richard** says yeah)) that's supposed we have the location we are able to see the location tomorrow	
36	Conor:	yeah	

In the extract 5.2.5, Richard, Aaron, Fred and Conor have been talking about the activities that must be covered for the assignment so make some decisions. In lines 1 and 2, **Richard** says, '*I think to put it like the reason we're doing it in Australia…*', sharing his thoughts about the task that could be seen as a kind of coordination construction stage with some sort of strategy that is followed by **Aaron**, in lines 5 through 12, when saying, '*so you want to stay more certain have six percent is like (…) this is what we've done it (…) that's why we have done it',* starting to build up an agreement around the decision that the team need to reach for the task that is being discussed, adding some information that could be understood as a knowledge sharing that is driving the group towards a common ground so a later agreement might be reached.

Then, in lines 13 and 14, **Fred** expresses his opinion about what Aaron has just shared, saying, '*aye I think that's quite a good way to do it'*, where the emergence of an agreement is starting to be shaped, that is endorsed by **Richard** in lines 22 to 25, '*yeah (…) yeah that's the whole points she'll try to get across*', pointing out to an element that plays an important role for the outcome of what is being discussed, what the subject lecturer could ask, being used as a standard reference. In a sense here, they agree that the location is important, but they have yet to make the final decision.

Furthermore, in lines 26 and 27, **Aaron** says, '*so the location is definitely one of them*', where the use '*definitely*' emphasises that an agreement might be imminent, which is confirmed by **Richard** in line 28 saying, '***yeah***', that may be seen as a simple affirmation, giving the impression of being just loosely following the conversation. Hence, **Aaron** continues to support his position by saying through lines 29 to 35, '*this is our location the reason I know she said that's only done* (…) *we have the location (…)*', displaying how concerned he is, in regard to what the lecturer could inquire and using it as a form of standard, which is agreed by Richard and Conor, this last one, who had been a silent participant until this point.

In extract 5.2.6, Emily, Liam, Adam, Robin, and Grant have been having some exchanges revolving around what market field their production should be sold for.

Extract 5.2.6. Group 4 – 35 minutes into the meeting 2 out of 6 – (300420)

Line	Student	Utterance	Theme
1 2	Nick:	**how can we explain** our reasoning though	**INQ**
3 4	Emily:	no we don't we can't say we are making nitric acid (laughter)	
5 6 7	Robin:	yeah I know but **what I am saying** is it's not specifically about fertilisers but (unclear)	
8 9 10	Nick:	but **you're saying you're saying** look at Germany if they need X amount per year	
11 12 13	Robin:	yeah **we are already doing** that most of it will be for tons per year or whatever else nitric acid	**ACK**
14	Nick:	okay	
15 16	Emily:	and what about the explosives in Germany	**INQ**
17	Robin:	don't know (contracting his shoulders)	
18 19	Liam:	that's so silly (laughter) well we just sell in Germany we're like	
20	Emily:	no	
21	Liam:	nothing else	
22 23 24	Robin:	unless we're selling it in the black market (laughter) that's going to be in that section	
25 26 27	Grant:	we're going to be there like (gangsters) who pops up like just say look get these free samples (laughter)	
28 29 30	Nick:	oh yeah like whiskey (mimics he's drinking whiskey) (In overlap - not clear)	
31	Grant:	oh here we have it	
32 33 34 35 36	Emily:	**we already know** what the demand is for nitric acid is because what **we've got to know** is how the market for nitric acid ((**Robin** says yeah – moving his head)) is in the UK and there ehm yeah	**ACK**
37 38	Adam:	of course we need to put some safety stuff	

Extract 5.2.6 presents a sequence of exchanges across the team, who have been discussing various items regarding the project. In line 1, **Nick** says, '*how can we explain our reasoning*', raising a question that requires the intervention of the team

members, bringing the participation of Emily and Robin through lines 3 through 7, where **Robin** replies in line 5, '*yeah I know but **what I am saying** is*', giving the impression that the members are trying to reach an agreement around a fundamental decision for the project completion.

What is more, again through lines 8 to 10 **Nick** says, '*but you're saying you're saying look at Germany if they need X amount per year*', paraphrasing a statement that Robin has made earlier before during the meeting, that challenges or questions the information that Robin has said, creating a discussion atmosphere among the team members that in reality, it is setting the bottom line to reach an agreement around a fact that seems to be logic, as **Robin** replies in lines 11 to 13, '*yeah we are already doing that most of it will be for tons per year or whatever else nitric acid'*, that is responded by **Nick** in line 14 saying, '*okay*'.

In lines 15 and 16, **Emily** asks, '*and what about the explosives in Germany*', where it seems that she is looking for getting a consensus around the team members, as there is a need to define the industrial sector, where what they plan to produce needs to be sold or commercialised, which is a decision that requires the interaction of a broaden number of members, not only the one from Robin, Nick, and herself, but Liam and Grant also; however, what **Liam** adds in lines 18 and 19, '*(…) well we just sell in Germany we're like*', seems not to be what **Emily** was expecting to hear back, replying in line 20, '*no*', expressing her disagreement in regard to what Liam has said. Simultaneously, the inquiry section that has been started by Emily in line 15 looks as if the students were triggering a transition into coordination construction, as there is an active interaction among them.

Nevertheless, through lines 22 to 31, the discussion turns into a banter, where some irrelevant comments are said by Robin, Grant, and Nick, that led **Emily** to say in lines 32 to 35, '*we already know what the demand is for nitric acid is because what we've got to know is how the market for nitric acid*', that in reality is settling the way for a decision to be made, where the use of '*we already know*', indicates that she is reminding them that what she is saying, the team members are aware of but there is still a task that needs to be covered, implying that an agreement around a relevant element for the project progress needs to be achieved as to support their work with feasible reasons.

Furthermore, **Emily** explicitly says in lines 33 and 34, '*what we've got to know is*', making it clear that the team members need to work on that activity, which is supported by **Robin** in line 35, saying, '*yeah*', while Emily is presenting her reason, which can be understood that an imminent agreement is nearly to be obtained, a common element that has been seen when an understanding around essential common knowledge is almost to be reached across the group members, that is later emphasises by herself in line 36 saying, '*yeah*', which indicates that an agreement has been reached. As the meeting continues, the group members follow their discussions but towards a different element.

4) Strategy Device – SD

This theme has been defined as how the students plan a set of tactics or strategies to complete the assignment. While analysing the data, it was apparent that two sub-types of strategies could be identified in the student's interactions; hence, the theme has been divided into two sub-themes, the first one, strategy device towards the content and the other, strategy device towards the task/goal. These two sub-themes are based on the type of approach that the students take while attempting their activities across the project meetings.

The two sub-themes are associated to applying strategies that might be oriented towards technical tasks (Content) or dealing with how to progress and complete the activities. As the orientation of the students varies in these two different contexts, it was necessary to make a clear differentiation on the use of strategy device. Furthermore, some utterances have been sometimes labelled as simply Strategy Device, because they are not evidently oriented and exclusively to task or other content.

The following sections present a description for each sub-theme, providing examples in the context of the research, showing how they occur as the project meetings take place.

A. Strategy Device towards the Content – SDC

This theme refers to approaches the team takes to address issues of content – e.g., how to solve a technical problem by performing a series of calculations.

In extract 5.2.7, a rich sequence displays the already introduced themes. In this excerpt, the conversation revolves around the preparation of the topics to be covered in a presentation for the project status to the class lecturer.

Extract 5.2.7. Group 4 – 13 minutes into the meeting 2 out of 6 – (020420)

Line	Student	Utterance	Theme
1 2 3	Emily:	the fact about Canada is cause they're producing between 1000 tons per day and 1500 tons per day	**KS**
4	Nick:	okay	
5 6	Emily:	and the plant that we are what we can do to work on that erm uhm	**ACK**
7	Adam:	in Germany	
8 9 10 11 12 13 14 15 16 17 18 19 20	Emily:	**yeah and they were operating at like** **100 they were operating up to 1000** **tons per day** ehm and then it literally has like what pressure over the reactor work like over that ((**Robin** says um-hum)) **and they were** **like isotropic something beneath I** **don't know well anyway** I didn't want to print up the entire document cos again **it was too much about something** **like** ((**Adam** says yeah)) **this** **presentation to get to that point** obviously like I knew it was there	**SDC**
21	Robin:	so which's the report	
22	Emily:	it's like on the main thing	
23	Robin:	this is this is like	
24 25	Emily:	I'll show you until that sheet that's the production	
26 27 28	Robin:	yeah I was looking through that just before I got here actually and ehm as well they talk about useful stuff ehm	

In extract 5.2.7, what concerns the strategy stage can be seen in **Emily**'s utterance, from line 8 to 20, where she starts by saying, '*yeah and they were operating at like 100 they were operating up to 1000 tons per day (…)*', which is connected to a reference that has been made by herself earlier in lines 5 and 6, '*and the plant that we are what we can do to work on that erm uhm*', and that shows how a strategy linked to the content for the presentation, that it has to be delivered, might be justified; however, this is then not about the problem at hand but related to the presentation.

Then, in lines 13 to 15, **Emily** says, *'and they were like isotropic something beneath I don't know well anyway (…)'*, where a strategic aspect could be connected to solve

a technical issue that has been drawn. Besides, in lines 17 to 19, **Emily** justifies what she has just said by adding, '*it was too much about something like (…) this presentation to get to that* point', framing that that source of information could be used later as a reference to deal with one of the project requirements, but that it was not yet needed at that stage of the project completion.

Furthermore, through lines 21 to 24, there is a series of exchanges between Robin and Emily, that are still connected to a form of construction of strategy device towards the content that can be seen in line 24 with **Emily** saying, '*I'll show you until that* sheet that's the production', mentioning a vital matter for the project, which is reinforced by Robin in line 26 saying, '*yeah I was looking through that just before I got here (…)*', that backs what Emily has said, which is a technical activity that the team need to do so to advance the tasks.

B. Strategy Device Task/Goal – SDT

This theme refers to approaches the team takes to progress the task and meet the goals, either immediate or overall and not linked directly with the content itself.

Excerpt 5.2.8 brings an exchange of strategies that have appeared as part of the meeting, showing how the group have been fully immersed in progressing the project activities both in ensuring that their solution is adequate and that they do the task in an expedient fashion, which is a strong characteristic that has been seen alongside the discussions.

Extract 5.2.8. Group 4 – 44 minutes into the meeting 2 out of 6 – (150520)

Line	Student	Utterance	Theme
1 2 3	Nick:	**'cos I think we need to get the way of producing ammonia or how much we're going to be charged**	**SDC**
4 5	Emily:	yeah 'cos every plant every plant is gonna have	**KS**
6	Nick:	we can get the other one	
7	Emily:	every plant is gonna have a supplier	
8 9 10 11 12 13 14 15	Nick:	Um-hum I thought about it and they are 'cos the only thing we're supposed to determine 'cos it's a bit difficult and **'cos the only thing we can do is like to have chemical for labs and that's like a small volume that you can buy anything else I mean is**	**SDC**

Line	Student	Utterance	Theme
16 17 18	Emily:	do we really need I guess **we could just kill off and we could we could explain** we've explained	**SDT**
19 20 21 22	Nick:	well I **went through legislation** for environmental stuff and then other documents yet **the question takes too long to say** that should be too bad	
23 24 25 26	Emily:	but does that mean something here as well with you ((**Nick** says yeah) and the environmental impact ((**Nick** says yeah))	
27 28 29 30	Nick:	and **I was gonna check it off all the stuff in one big document** just so you know something **we could dish at the tasks at once we go about**	
31 32	Emily:	so you think to do all in the ((**Nick** says yeah)) just give me a shout	

Extract 5.2.8 begins with **Nick** saying, '*'cos I think we need to get the way of producing ammonia or how much we're going to be charged*', that have been labelled as SDC because it is about what to do in terms of solving the technical problem instead of how to achieve the goal/tasks, which could be compared to what he says in lines 11 through 15, specifically, in the section 10 to 14, when he says, '*(…) 'cos the only thing we can do is like to have chemical for labs and that's like a small volume that you can buy anything else I mean is*', showing a clear intention to solve the tasks by clustering them, and focusing the effort towards a single goal, rather than any other, being a strong strategic feature.

Furthermore, in lines 16 to 18, **Emily** reinforces the strategy when saying, '*(…) we could just kill off and we could we could explain (…)'*, drawing her intention in keeping moving the group activities and looking on how to support their decisions. Also, **Nick** keeps drawing his strategy towards the goal, saying through lines 19 to 22, '*I went through legislation (…) the question takes too long to say that (…)*', expressing what he has been doing and what challenge the question in discussion has posed for its completion, according to his knowledge and expertise.

Also, in lines 27 to 30, **Nick** says, '*and I was gonna check it off all the stuff in one big document (…) we could dish at the tasks at once we go about'*, being a clear approach to complete the tasks and mark them off as done, that could be understood as an incentive to keep the work among the team up. In addition, what Nick has just said

generates a response from **Emily** in lines 31 and 32, saying, '*so you think to do all in (…) just give me a shout'*, offering him her support, aspect that could strength the strategic aspect that has been discussed, and at the same time, exemplified synergy towards the creation of a strategy to do the task.

Extract 5.2.9 brings an example where it has been identified the occurrence of both strategy device subthemes across the team discussions.

Extract 5.2.9. Group 4 – 56 minutes into the meeting 2 out of 6 – (040221)

Line	Student	Utterance	Theme
1 2	Adam:	**I think we should go for** Germany and **then we just see** the capacity	**SD**
3 4 5 6	Grant:	yeah I've worked I've worked as long as the slide for sure for 24 hours there's no point in holding the whole that for 24 hours	
7 8	Nick:	who's who's gonna write why we should go for Germany	**SDT**
9	Emily:	me (laughter)	
10	Nick:	okay right	
11 12 13 14 15 16 17 18	Grant:	yeah so **I'll go check** the price and see if there are differences in the purity of EU prices also ((**Nick** says okay)) **I'll double-check** the grades they all are using and then what sort of HAZID I'll have that for Friday I can write some basic like ideas regarding nitric acid	
19 20 21	Emily:	I think that the other thing **we need to remember** right is kind of short we've not got a lot of time	**SD**
22	Adam:	yeah	
23 24 25 26 27	Nick:	yes ((**Adam** says uhm)) I think that the presentation is like I supposed to be kinda like you've only got to go like say this cost this much this cost this much as long as you want	

In extract 5.2.9, it could be read how **Adam** in line 1 says, '*I think we should go for (…)'*, where the use of '*we should go*' is an indicator of a strategic element that could be either connected to the content, that has been identified when exploring different segments of the students' meetings, which is further reinforced in line 2 when saying, '*then we just see the capacity*', or implying that in that moment they should be focused on one task and later, address another one. Then, in lines 3 and 4 **Grant**

says, 'yeah *I've I've worked as long as the slide (…)*', showing that he has been doing some preparations for the file that is going to be submitted as part of the project activities.

Additionally, throughout lines 11 to 18, **Grant** sketches a strategy that is related to the task of what should be considered for one of the activities by saying, '*I'll go check (...) I'll double-check (…) I'll have that for Friday'*, keeping on drafting his strategy towards the task, being supported, and somehow, endorsed by adding, '*I can write some basic like ideas*', where there is sharp strategy so to address what is being required.

Afterwards, in lines 19 to 21, **Emily** says, '*I think that the other thing we need to remember right is kind of short we've not got a lot of time'*, which could be seen as strategic element that seeks for calling the attention of the group, keeping in mind what constraint could limit what they can and cannot do based on their performance, which is agreed by **Adam** and **Nick** in lines 22 and 23. In lines 23 to 27, **Nick** adds up more details to the strategy that Emily has previously started to devise, saying in lines 25 and 26, '*(…) you've only got to go like say this cost this much this cost this much (…)*', as if he were suggesting a speech for what needs to be delivered, where there is a display of intertwine strategies for both, content and task.

5) Inquiry – INQ

This usually happens when a concept or process is not clear, or when someone is explaining a point but for any reason extra clarification is needed. Also, inquiry refers to questions that trigger other actions.

In extract 5.2.10, the occurrence of the inquiry theme is presented:

Extract 5.2.10. Group 4 – 43 minutes into the meeting 2 out of 6 – (150520)

Line	Student	Utterance	Theme
1	Liam:	a lot of people are doing the same	**SDT**
2 3 4	Nick:	yeah yeah and then you go and get the same parameters (laughter) if you can see Sigma Aldrich	
5	Grant:	(unclear)	
6 7 8	Nick:	I don't see it in Google **I mean that's what I don't understand I don't understand where**	**INQ**
9 10	Adam:	**where we're going to get the information**	
11	Nick:	yeah where we're going to get	

Line	Student	Utterance	Theme
12		everything else	
13	Emily:	I'm OK looking for that	

In extract 5.2.10, the first segment of the excerpt has been labelled as strategy device towards the task, where in line 1 **Liam** says, '*a lot of people are doing the same*', displaying a strategic element towards the use of a reference related to what other teams dealing with the same assignment have been doing, which could be seen as a tactic that could help them to complete the task; however, through lines 2 to 4 **Nick** says, *'yeah yeah and the you go and get the same parameters if you can see Sigma Aldrich',* challenging the approach that Liam has said in a comic manner, but that in reality is assessing the usefulness and actual possibilities of such a method.

Subsequently, **Nick** in lines 6 to 8 raises a question, '*I don't see it in Google I mean that's what I don't understand I don't understand where*', aspect that is related to a source of information that could be used for addressing one of the tasks, the location for the plant and design to be proposed as part of the project. By doing so, it seems that he is not the only one with the same doubt, since **Adam** asks in lines 9 and 10, '*where we're going to get the information*', illustrating the importance of questioning what is being carried out, and what set of strategies or tactics, the group could deploy for solving the task. Similarly, **Nick** says in lines 11 and 12, '*yeah where we're going to get everything else*', backing Adam's claim; thus, Nick and Adam seem to agree that it is not clear where they might be obtaining the information needed; request, that in line 13, is somehow answered by **Emily** saying, '*I'm OK looking for that*', trying to ease her colleagues' requirements.

Extract 5.2.11 brings a series of utterances, where the group members are raising some questions about the product that is going to be produced as part of their project proposal.

Extract 5.2.11. Group 3 – 27 minutes into the meeting 3 out of 6 – (220721)

Line	Student	Utterance	Theme
1 2 3	Richard:	**what was your thought** Jamal what you think about the price for ammonia that you came across with	**INQ**
4 5	Jamal:	no this is this is like the cost the cost of ammonia and decreasing	
6	Fred:	I remember finding that so but	**KS**

Line	Student	Utterance	Theme
7		they're not that I mean issue for us	
8		but that might make Yara more there	
9		are two more to it before they get	
10		the so they might want to actually	
11		use their ammonia and sell something	
12		else which wasn't working like that	
13	Jamal:	yeah because it'd involve having like	**SDC**
14		OK if it's all full this price we'll	
15		have **we'll we'll do this strategy we**	
16		**have to have like an ABC and we can**	
17		**do that** in the word (unclear) based	
18		on hyper because addition so yeah	
19		there's only so far your work can	
20		help with that	
21	Aaron:	**have you guys got anything you want**	**INQ**
22		**to bring up this time or catch us up**	
23		to speed on you then leave the	
24		capacities in there because	
25		**everything else in there is fine**	
26	Richard:	**have you ever double-checked over**	
27		**units** on the (unclear) which it right	
28		which I don't know like you did you	
29		get the CP values from (unclear)	
30	Conor:	yeah ((**Fred** says yes))	
31	Jamal:	they're in like kilojoules per	
32		kilograms	

In extract 5.2.11, starting in line 1, **Richard** asks Jamal, '*what was your thought Jamal what you think (…)*', directing a question that brings up an activity that Jamal might have been working on, and it seems to be the time to incorporate that information into the project report, with **Jamal** replying to Richard in lines 4 and 5, '*no this is this is like the cost the cost of ammonia and decreasing*', event that prompts the team members' participation, leading to a sequence of exchanges in the subsequent lines, conveying information that could be seen as a knowledge sharing stage from line 6 through 12.

As a result of what Fred has expressed, **Jamal**, starting in line 13, presents a type of strategy connected to the content of what is being addressed, saying in lines 15 to 17, '*(…) we'll we'll do this strategy we have to have like an ABC we can do that in the word (…)*', being an instance where there is a well-defined strategic aspect that aims to tackle a vital task for the project, which is the definition of the price of the good that is supposed to be produced by the design plant the team should propose. In addition,

Jamal sketches a strategy that points out to the participation of the team members, as there is unbroken use of the '*we*' pronoun, implying and exercising a form of shared regulation toward his peers.

Furthermore, in lines 21 to 23, there is an inquiry instance, where **Aaron** makes a question to the whole group, '*have you guys got anything you want to bring up this time or catch us up to speed on you*', which could be seen as a clear way to grab the team's attention to move on as the activities seem to be fair, and another ones could require to be checked by adding in lines 23 to 25, '*then leave the capacities in there because everything else in there is fine*', making clear that what has been discussed does not require more attention.

Consequently, what Aaron has asked, triggered a response from **Richard** to ask in lines 26 and 27, '*have you ever double-checked over units*', which could be understood as a quality control strategy and monitoring, referring to a previous similar task through lines 27 to 29; question that in lines 30 to 32 is replied by Conor, Fred, and Jamal.

6) Group Operation – GO

This theme is defined as how the students agree to manage the group, and the roles that each member assumes as the project development takes place.

This theme has been identified in several parts of the data corpus, reflecting on the importance of the definition of roles that students assume, and particularly, what refers to student ownership.

Extract 5.2.12 is an instance of the group operation theme:

Extract 5.2.12. Group 4 – 47 minutes into the meeting 2 out of 6 – (090620)

Line	Student	Utterance	Theme
1	Nick:	I know I know other parts where	**KS**
2		they're just using using that steam	
3		to produce literally as our utility	
4		((**Emily** says yeah)) because you know	
5		((In overlap – not clear)) because in	
6		the plant energy in as in the energy	
7		you put in no matter how you're	
8		putting in ((**Adam** says yeah)) it's	
9		always the same you know wha' I mean	
10		you can use it to power ((**Grant** says	
11		yeah)) something you can use as heat	

Line	Student	Utterance	Theme
12		heating something like like inside	
13 14	Emily:	**so who'd look at who would look at that**	**GO**
15	Robin:	I've got it	
16 17 18 19	Adam:	**and for the presentation I´ve written stuff on it and how how's going to be addressed that part** ((**Emily** says steam)) **steam**	**SDT**

Excerpt 5.2.12 shows the roles setting for the preparation of the project. Throughout line 1 to 12, the extracts starts with Nick saying, '*I know I know other parts where they're just using using that steam to produce*', sharing some information that could be relevant to their project and that is related to how some plants that he has probably read or researched about it have used a by-product, keeping the attention of his peers, who seem to follow what he is saying.

Then, **Emily** enthusiastically asks a question in lines 13 and 14, '*so who'd look at who would look at that …*', which has been triggered by the previously utterance, where **Nick** has been sharing his knowledge regarding a process, question that is replied by **Robin** in line 15 saying, '*I've got it'*. An aspect worthy to highlight is the way **Emily** poses her question, which is a good example of how vital is for a group to define in early stages, what needs to be performed and who will do it.

Additionally, in lines 16 to 19, **Adam** adds up to Emily's question, '*and for the presentation I´ve written stuff on it and how how's going to be addressed that part ((***Emily** *says steam)) steam*', pointing out that certainly, some members have already assumed specific roles that have not been 'officially' assigned, or even, that Adam has taken on himself or has been assigned earlier. Also, Adam just confirms what he has done himself, but it is not clear here if these were unofficial assigned tasks or he has simply volunteered.

In extract 5.2.13, the group have been making some arrangements before the submission of the report.

Extract 5.2.13. Group 4 – 35 minutes into the meeting 5 out of 6 – (150421)

Line	Student	Utterance	Theme
1 2	Grant:	well **we'll probably have** on Thursday to do the mass transfer stuff back up	**GO**

Line	Student	Utterance	Theme
3 4		match transfers and all back one day go like that	
5 6 7 8 9	Emily:	'cos we need to have a lot of information at this point like our utilities freaked out and like all I feel like that's what we need in order to be able to do this	
10 11	Nick:	she's doing ethics instead because the (unclear) is the forecast coming	
12 13 14	Adam:	well there should be done by the way on the 25th the day before our presentation of the (unclear)	
15 16	Nick:	I've got a game for that afternoon so let me hear anything good	
17 18 19	Emily:	I have a quiz that we do in the morning Sunday if possible well what time did you on the Monday	
20	Robin:	what's on the presentation	
21	Liam:	well this one over there	
22 23 24	Grant:	I'm leaving Sunday morning so **we have some** more so we have three more contact and then yeah	
25 26 27 28 29	Emily:	hello I'm out for lunch on Saturday but I'll come and stay after or on before getting like free also actually whatever I just need to leave the event	
30 31 32	Grant:	okay so maybe I'll take five days on Saturday next time then maybe we need to Sunday morning 7	
33 34 35	Robin:	**we've got red cards** ((**Emily** asks are we going to university now)) the library it's really transferable	**GO**
36 37 38 39 40	Nick:	yeah yeah the red card ((**Grant** says Rambo - laughter)) okay I'll just get more accurate unless I mean surely they're like if one of you have a red card and I meet you at the front door	
41	Grant:	yeah it's got your name on it	
42 43 44 45	Nick:	**I have a check** that you can if you can get lucky and the guys on there ((**Grant** says yeah)) David they let their little guys	
46 47 48 49	Grant:	this is it will let you just go up to the desk with the Chemical Engineering Department office and go kind of get around	
50	Liam:	where is that	
51 52	Nick:	because they were releasing their design attributes to (unclear) so I go	

Line	Student	Utterance	Theme
53		in and say can I get one of the cards	
54		I get rid of the card ((**Grant** says so	
55		like yeah sure)) what do you study for	
56		your student cards and then just write	
57		one for you ((**Grant** says that's it	
58		right cool)) **I'll do that tomorrow**	
59	Emily:	so well thank you	
60	Robin:	before we talk it's like so the weekend	
61		on Saturday will do they will date and	
62		then if we need to Sunday morning as	
63		well and ideally don't want to	

In excerpt 5.2.13, although how long that could look, the team have been organising their activities as the submission of the project report is soon approaching. Through lines 1 and 2, **Grant** is bringing the attention of the group when saying, '*we'll probably have on Thursday to do the mass transfer stuff*', suggesting that some activities still need to be addressed but without assigning or mentioning a specific team member this task, and rather referring it to the whole group, which could be seen as an indicator of how some tasks have been assigned, although there is not a direct ownership of them.

Subsequently, in lines 5 and 6, **Emily** adds up her own reflection type by saying, '*cos we need to have a lot of information at this point'*, which might imply that some activities are yet to be completed and also, with the use of '*at this point'*, referring to the project timeline and the proximity of its submission. Furthermore, in lines 7 to 9, she adds, '*(…) I feel like that's what we need in order to (…)*', posing the need that the completion of the activities is required to finish what Grant has just stated. Then, **Adam** says in line 12, '*well there should be done by (…)*', being clear that by a specific time, what Grant and Emily have said it has to be completed.

The subsequent lines (15-32) are not connected to the project itself; however, they show how the team members try to organise synchronically their activities and personal engagements so to be working towards the last stages of the project.

Robin in line 33 asks, '*we've got the red cards'*, which is a card that grants access to certain university buildings after working hours and weekends, and that sings post how the team members are moving to a different location, when **Emily** asks in lines 33 and 34, '*are we going to the university*', that could be seen a bit odd as they have been working in one of the buildings of the university, but what she might be referring

to is the building where the engineering faculty is located within the premises, which is answered in lines 34 and 35 by **Robin** saying, '*the library*'; thus, it is clear that the group intend to use a different place to continue their work.

After this, throughout lines 42 to 45, **Nick** says, '*I have a check (…)*', offering himself to check how the access works that could be understood as a manner to make sure there is no disruption in the group dynamic, emphasising it in line 40 by saying, '*I meet you a the front door*', utterance that is linked to a collaborative element in the group dynamic, which is further validated by himself in line 58, '*I'll do that tomorrow'*, taking on that task.

Across lines 60 to 63, **Robin** makes an implicit reference to some sort of tasks that might require to be completed during the weekend by saying, '*on Saturday will do* (…)', and then adding, '*if we need to Sunday morning*'; however, aiming that they have finished the pending activities in one day, which is immediately reinforced by saying, '*ideally don't want to*', so to avoid working both days, which could serve as a standard or encouragement for the team to work efficiently as possible.

7) Referencing – REF

This theme is related to the elements (e.g., books, other peers, websites, and tutor) that students refer to as a source of information, explanation, clarification, and even, reflection.

Referencing has been commonly observed when exploring at first the project requirements, and when the groups have explicitly mentioned other groups work, information from companies, when referring to the class lecturer, which is a common element found in the data corpus, and when going back to agreements or decisions that have been already made in the past.

Extract 5.2.14 presents the occurrence of referencing in one of the student's meetings.

Extract 5.2.14. Group 4 – 46 minutes into the meeting 2 out of 6 – (250520)

Line	Student	Utterance	Theme
1	Emily:	**is my case is is our case 14** there	**GO**
2		because **I had about 14 million graphs**	
3		**that I put into that are now printed**	
4		**and shared** for regeneration of nitric	
5		acid (in overlap - not clear) I don't	

Line	Student	Utterance	Theme
6		know why	
7 8 9 10	Robin:	I don't know I´m not gonna say I'm not gonna say that because I think the term consumption it's to mention that stage	
11	Nick:	yeah yeah	
12 13	Adam:	yeah just type the consumption consumption of nitric acid	

In Extract 5.2.14, in line 1 **Emily** has started referring to some exercises from the subject by saying, '*is my case is is our case 14 there',* indicating a strong use of what has been instructed in class in the previous semester through PBL cases, and that could be helpful for the project completion.

Also, in lines 2 to 4, **Emily** uses the word '***graphs*', saying, '*I had about 14 million graphs that I put into that are now printed and shared…*', which from the context of the meeting, it is information that has been taken from the case she has just mentioned and that has been covered in the class, and that could be clearly used by the team. Also, the phrase said by Emily in lines 3 and 4, '*now printed and shared*', indicates how the group organise their documentation and share it, a neat example of group operation.

Extract 5.2.15 brings a discussion around an activity that Emily, Nick, Adam, and Grant are having and that is vital for the conception of the design to be proposed.

Extract 5.2.15. Group 4 – 1 hour 3 minutes into the meeting 2 out of 6 – (180321)

Line	Student	Utterance	Theme
1 2 3 4 5 6	Emily:	uhm the thing **I was going to ask** we could use ((**Grant** says yes)) so **having like** consumption and **capacities from like 2012** is like absolutely okay to think about as a criterion for this	**INQ** **SDC**
7	Nick:	yeah where is it where	**INQ**
8 9 10	Emily:	Nah 2012 was more than five years older think about the difference between 1995 and 2000 or like	**KS**
11 12 13	Adam:	I guess well I don't really know a lot I truly want to kind of cut off or like reliable statistics	**CC**
14 15 16	Emily:	two each for example for the fourth year they're doing a project right now and one guy tried to do a market	**REF**

Line	Student	Utterance	Theme
17		evaluation based on stuff from 2015	
18		and his work was absolutely stuck in	
19		and he said he couldn't put it in	
20		there because it was not too easy and	
21		it was for the last two years	
21	Grant:	you probably won't be looking at	**CC**
22		depending on what's changed since	
23		then so if that was 2012 and then it	
24		went really fast 2012 that's fine	
25		((**Emily** says that's fine)) but if	
26		like it was to use like two easy	
27		*super flats built by these*	
28	Nick:	yeah so you don't take everything	
29		it's just like current like ((**Adam**	
30		says yeah))	
31	Emily:	yeah	
32	Grant:	yeah	

In line 1 of Extract 5.2.15*,* **Emily** starts to introduce a question that could be assumed as a suggestion saying, '*I was going to ask we could use (…) so having like consumption and capacities (…)*', where she uses '*we could use'* as a subtle suggestion, but without making it explicit, or imposing her idea, which is later complemented in line 5 by adding, '*to think about as a criteria*', that is in certain way a strategic feature; then, in line 7 **Nick** asks **Emily**, '*where is it*', who replies back in lines 8 and 9, '*2012 was more than five year older to think*', bringing up some knowledge about her source of reference and somehow, judging the relevance of her contribution.

Through, in lines 11 to 13 says, **Adam** says, '*I guess well I don't really know a lot I truly want to kind of cut off or like reliable statistics*', exercising a form of coordination, which is directly related to the consistency of the information that is being used, serving as a valid argument to what the group aim to accomplish.

Subsequently, from line 14 to 21, **Emily** makes explicit reference to an upper year of the same undergraduate program, '*they're doing a project*', where is evident the use of an external element to progress their work, bringing some elements that might serve their goals, presenting factual information that someone has shared with her, '*one guy tried (…) it was not too easy*', that has been data that have researched about them, and that could potentially help the group make better decisions and get a better project development, which is an element that has been evidenced in different

sections of the meetings, the constant use of sources of information, other groups of students, the subject lecturer, among others.

In addition, throughout the data analysis and coding, it has become noticeable that the students' interactions associated to shared regulation do not follow a linear sequence as per the models available in the literature (e.g., Hadwin and Järvelä (2018)), but they are naturally intertwined so that changes in patterns are common and sometimes unexpected, altering and redirecting the flow of the conversation. The previously said, it could be exemplified in extract 5.2.15, where there is an unmistakeable identification of different themes that fluctuate from one to another, in a non-sequential series, where a segment could have a combination of inquiries, with some sort of knowledge sharing and strategy device, that then, could go back to a questioning setting, followed by a knowledge sharing sequence, which simultaneously, it is accompanied by a coordination construction utterance, jumping into a reference stage that easily could return to a coordination construction segment to go through an agreed common knowledge point, showing the complexity, and at the same time, the richness of human interactions, where their progression and devolution are intrinsically twinned.

As a result, it is imperative to say that some themes can be identified in single utterances but not all of them; this is case of coordination construction, which requires the interaction between members of the teams, which also applies to group operation, involving a transversal form across the utterances of students interactions and transactions.

Figure 5.2 is a diagram that sketches how the themes have been allocated based on their inherit nature, the correlations that could exist among them, and the links that have been established in association to the overarching or main themes.

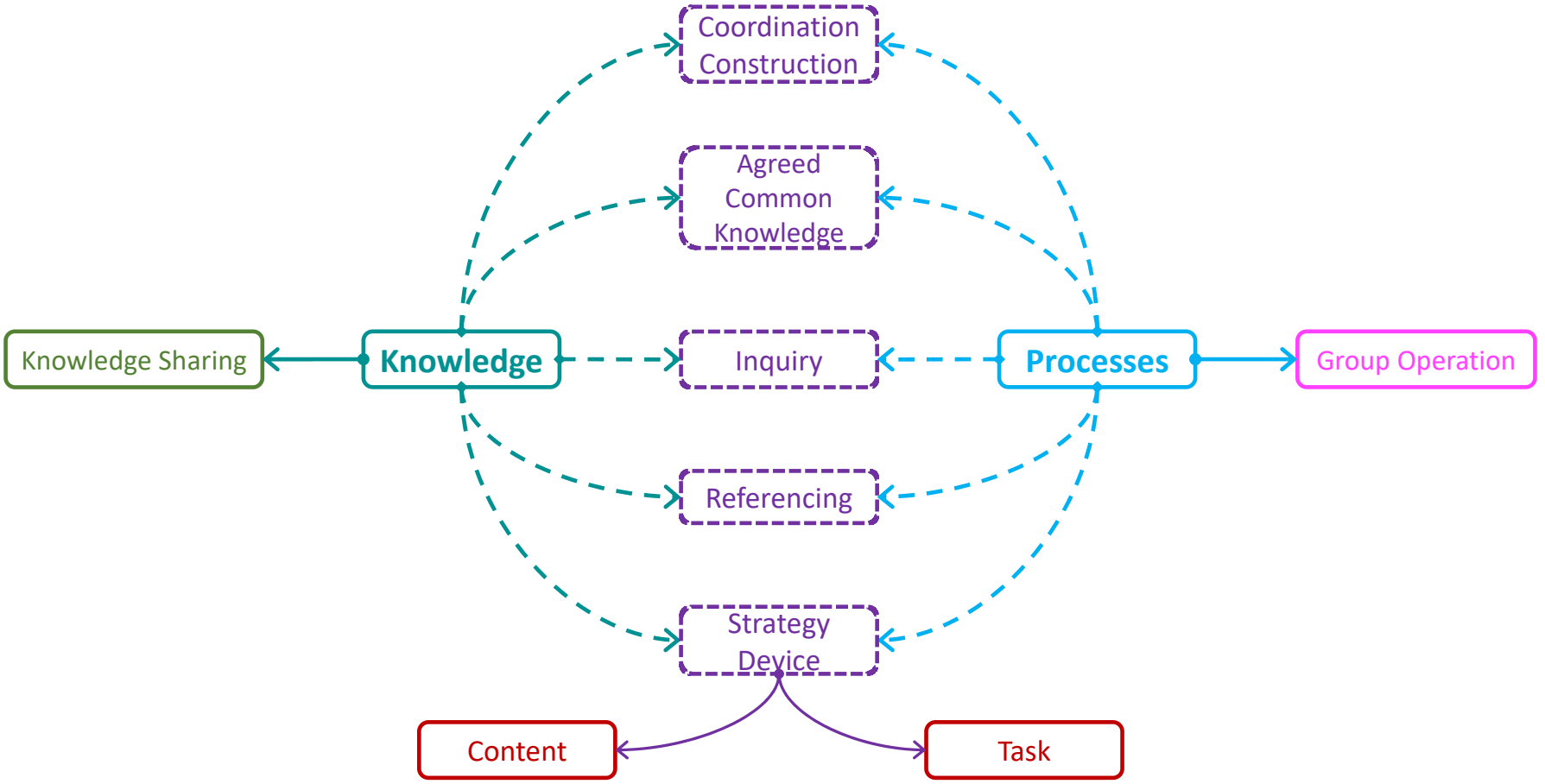


Figure 5.2. Relationship of the themes for the shared-regulated learning model

On the left-hand side of figure 5.2, the main theme knowledge in dark green is located, connecting to the knowledge sharing theme in cyan; it is also linked through a green dotted line to the five dotted purple themes, coordination construction, agreed common knowledge, inquiry, referencing, and strategy device, which are found at the centre of the diagram, given their intertwined association. Likewise, associated to the strategy device theme, on the centre bottom, its own two subthemes in red, task and content, are located.

Correspondingly, on the right-hand side in blue, the other main theme processes component is situated, connecting to its left-hand side to the centred purple sub-themes that were already introduced, and also, on the right-hand side to its violet-colour theme, group operation.

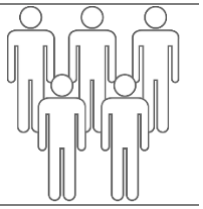
All these themes have become apparent from the analyses of the data, being common topics across the different students' project meetings, reflecting the complexity of their interactions, how the conversations could vary from one topic to another, and even, go back to initial conversation stages that were thought to have been concluded.

A remarkable and worth point to be mentioned is that these themes could be thought as belong exclusively to one or another of the overarching components, knowledge and processes; nevertheless, as it has been shown in figure 5.2, some of the themes are related to both components, which could be mainly due to the intrinsic nature and dynamic transactions of the students' exchanges, where the establishment of a crystal clear border that could possibly divide or even group the themes to one sole component is almost impossible, as it has been witnessed the implicit, complex, and intricate level of collaboration and communication among the team members.

Table 5.1 is a compilation of the whole set of sub-themes, with their own definitions, codes, and symbols. This table was used during the data sessions and data analysis stage, serving as a useful reference point when the identification process of the themes was taking place so to avoid confusion when spotting them; thus, making the process smooth and more structured and also, helping during the definition and refining period.

Table 5.1. Themes for the shared-regulated learning scheme

Theme	Code	Sub-theme	Definition	Symbol
1. Knowledge Sharing	KS		This theme is meant to be the moment when students share their conceptual knowledge about a topic	
2. Coordination Construction	CC		Denotes the instant when students after sharing their ideas, building up knowledge to a point of agreement, where coordination means that more than one person is being involved in the process	
3. Agreed Common Knowledge	ACK		Referred as the moment when students reach a mutual understanding after having shared and discussed a topic, task, or any other activity. It can also refer to points where decisions are made	
4. Strategy Device	SD		Defined as how the students plan a set of tactics or strategies to complete the assignment	
	SDC	a. Content	Refers to approaches the team takes to address issues of content – e.g., solving a technical problem	

Theme	Code	Sub-theme	Definition	Symbol
	SDT	b. Task / Goal	Refers to approaches the team takes to progress the task and meet the goals either immediate or overall	
5. Inquiry	INQ		This usually happens when a concept, or process is not clear or when someone is explaining a point but for any reason needs extra clarification	
6. Group Operation	GO		Defined as how the students agree to manage the group and the roles that each member assumes as the project development takes place	
7. Referencing	REF		This theme is related to the elements (books, other peers, websites, tutor) that students use as a source of information, explanation, or clarification	

5.3 Summary

This chapter has gone through the analyses, discussions, and developments, which have taken place for the conception, definition, and refinement of a set of common themes. These themes have been extensively assessed, and then, applied across the whole data corpus in a students' project setting, with the solid conceptualisation of a research model for the study of shared regulation of learning in teamwork.

Furthermore, the chapter has presented substantial examples that have been taken from the data corpus, providing support of how the proposed model, that is as an essential outcome of this study, has been intensively explored, exploited, and refined.

In addition, the model that has been proposed in this research is ready to be studied, applied and even, adapted to the shared regulation field in the context of teamwork research.

The upcoming chapter (**6**) will present and discuss the main results of this research, bringing a series of arguments to the findings of this study.

6. Discussion

This chapter presents a discussion of the outcomes of this research, which have been already described in **Chapters 4** and **5**, offering valuable insights onto how the data have been approached, the initial models and schemes that have been explored, and that have led to the proposal of a set of fit-for-purpose components and a research model.

6.1 Implicit and explicit elements within shared regulation of teamwork

This research has taken place using as the basis, the studies that have been found in the literature, and that have provided an array of references about how academics and researchers have defined, conceptualised and ultimately, built their own models and schemes, which in the great majority of the cases, have been based on previous studies, their own concepts, experiences, and even, some made-up interactions, as it has been reported in a couple of references (Schoor, *et al*., 2015); thus, all of these models or conceptualisations have served as the starting point to grouping common patterns, that later could be drawn from the transcriptions during the data sessions.

6.1.1 Järvellä and Hadwin's model exploration

Figure 6.1 illustrates the preliminary categories that have been used from the work executed by Järvelä and Hadwin (2013), and that have been initially used in this study, under which, elements of the students' interactions were allocated during the earliest stages of the research.

The four elements displayed in the cycle, perception, goals and plans, strategies, and adaptation, have served as the pillars upon which the shared-regulated learning (SSRL) process takes place (Miller & Hadwin, 2015; Mohd-Yusof, 2017), noting that they are interrelated, but not necessarily are going to be displayed in a specific sequence.

Figure 6.1. Phases of SSRL model – Adapted from Järvelä and Hadwin (2013)

Equally important, Järvelä and Hadwin's (2013) model being a theoretical structure, where the stages are expected to occur one after another as seen in figure 6.1. Consequently, due to the nature of the data corpus explored in this research, the use of the model has been limited as it has not been possible to identify in naturalistic settings the elements propossed in Järvelä and Hadwin's (2013) model.

The previously said has been due in part to the richness of the data corpus, but mainly to the intricacy of the students' interactions, which are displayed in a varied, and even sometimes, intertwined manner in a real class setting, as they would normally occur in human conversations and interactions, and that are much more complexed in every single sense, where those exchanges and transactions hardly follow a sequential structure, from one stage to another, and so on and so forth.

Furthermore, the appearance of the Järvelä and Hadwin's (2013) model elements, as shown in figure 6.1, and according to their studies, are directly connected to which stage the topic discussion is at; however, this assertion has been hardly observed in the data corpus of the students' project meeting sessions, where depending on the students' awareness, knowledge, and involvement in the assignment (i.e., familiarity

with the requirements, notions of what should be solved), their discussions and exchanges can go into and fluctuate between more than one of the four categories at the same time.

Therefore, when trying to label speech utterances within certain category, taking as a reference the definitions given to each category and pair them with what has been expressed by the students, Järvelä and Hadwin's (2013) model falls through.

As a result, the elements shown during the audio- and video-footage recordings were not possibly grouped strictly following Järvelä and Hadwin's (2013) model; moreover, this phenomenon has been mostly supported by the dynamic nature and the complexity of the interactions among the team members, as sometimes, the conversation might go even off topic, or even the specific elements could be related to other domain. Aspects that have driven the research into a more organic approach, where the data corpus richness could be explored and considered from a different position, avoiding limitations and misinterpretations of the students' learning phenomena.

6.1.2 Schoor's scheme assessment

After the exploration and the attempts to use Järvellä and Hadwin's (2013) model, and reaching out the conclusion of its unsuitability, CASoRL model (2018) , as it was already introduced in section 4.1, was then explored and used during some of the earlier data sessions held across this research, where excerpts of the students' conversations from their project meetings were discussed, amended, and analysed.

Nevertheless, the elements displayed in the students' conversations could not be readily classified into the categories of the Schoor's (2018) coding scheme, since the data themselves did not adjust well to the overarching components of it. Subsequently, it was comprehended that CASoRL model (2018) suitability was constrained, mainly due to the possibility of categorising the students' instances following the model instructions, as there was not a neat description, or even a solid representation through its architecture of what in reality the extracts were presenting, students having a series of vibrant discussions, disagreements, and a sort of real exchanges, which resulted constraining the needs of this research.

In fact, the exchanges around the project assignment activities that the students were dealing with, were much more complexed than originally thought to be exclusively

framed using a preestablished model that could be seen as a theorical structure, created based on made up interactions, trying to reflect on natural dialogues that turn to be more complexed to be drawn up under a rigid and set structure.

Consequently, Schoor's (2018) model has hardly suited the needs of the research, where it has been imperative to allocate and describe under a research structure the different elements that have been purely identified across the data corpus. As a result, the conception of a more grounded scheme, being the product of real conversations and occurring transactions in the context of teamwork has been apparent.

Subsequently, it was decided to conduct a further and deeper exploration and analysis of the data collected, applying an inductive approach, where the data have been considered without any prior concept from the available literature. Thus, it was realised the primary need of proposing a structure that was a pure reflex of the empirical data themselves, with the incorporation of some elements from previous research, that could be used to explain and exemplify, in a much more detailed and accurate way, the different stages that the students' conversations and interactions went through along the project meetings.

Once an initial scheme was sketched through discussions and examinations of the data, an iterative and intensive process took place along the data sessions and research discussions, that have effectively led to the proposal and conception of a bottom-up and top-down model, which is a much closer structure that could support and satisfy what the research has envisaged, helping both, describe the students' actions and serve to capture the regulatory elements of their learning progress as it has been shown in the data themselves.

As a result, the implicit and explicit component, that was previously introduced in section 4.5, has been primarily proposed grounded on the actions of the students – identified through their speech. Also, the implicit and explicit component has been adjusted, reorganised, and amended to satisfy the needs of the research, process that has happened along the data sessions as the implicit and explicit elements were identified in the students' dialogues, resulting in a more appropriate structure for coding some of the observed elements associated to the regulation stage in the students' dialogues. Consequently, probing the difficulty of labelling utterances within an exclusive and predefined scheme, when the interactions and transactions that are happening fluctuate in a more complex array as it has been recognised.

The following sections will discuss the findings in more detail.

6.1.3 Phases component

Throughout the students' conversations and interactions, the elements of the phases component, as it has been shown in figure 4.1, the phases were expected to have been identified from the earliest stages of the research; however, the model initially thought appropriate as it has been structured and defined by Järvellä and Hadwin's (2013), shortly posed a challenge for the way the data corpus was intended to be explored and analysed.

Students' interactions so conversations have taken place following a series of elements, which in the great majority of the time were connected to the project assignment, serving as the main backbone aspect across the meetings. From earlier project meetings, students have focused their attention on the tasks that had to be completed for the assignment, such as the definition and understanding what the tasks entailed and asked for, what sources of information they had available, and what needed to be searched for, who was to be doing what and what the deadline for those tasks were, if any had been agreed, to mention a few of the major activities that were required for the project completion.

An aspect that was evident along the students' conversations and that has been noticed in both focus groups, was how easily and continually the conversation topics changed from time to time, and even, sometimes being moved to subjects totally unrelated to the assignment, which could be seen as an intrinsic social aspect, and also, a significant way to ease so facilitate the group dynamics (Lovgren & Racer, 2000).

The conversation analyses have made evident how the students' interactions are continuously revisiting and going back to the task definition stage, being one of the most relevant stages while undertaking the assignment; this has been identified happening at instances that were oriented towards a strategic setting, making it hard to claim that a section of the students' conversation was a solely phase. At first, it could have been thought that the different phases would happen one after another, as if they were evolving as the activities were undertaken; however, human interactions do not occur in such a manner; thus, the stages that had been displayed

by the students during the project meetings have been identified during the data sessions in an assortment of combinations and occurrences.

Moreover, the task definition stage has not been exclusively seen in the primary meetings, but also in the last of them, where students have kept checking and revisiting the activities as a manner of keeping a control-type point, probably; an aspect that could be understood as part of the need of sustaining a revision of the activities progress or even, a lack of preparation for the meetings.

When looking at the goals and planning stages, it has been identified that they are strongly linked and intertwined to the task definition period, where the groups' members have previously defined what they wanted to achieve by the end of the assignment, mostly concentrated on the satisfaction of the minimum requirements that had been explicitly set in the project guidelines; being this fundamental to the dynamics and progression of the groups.

An aspect that was very much recurrent during the project meetings, occurring in both groups, was how concerned students were regarding what feedback and grades their work could be given by the lecturer, and if what they were doing was to be enough to satisfy what the marking criteria had set out, which at the same time has a strong connection with what the team members, individually, wanted to achieve with a special interest in the score that their effort could be entitled.

Consequently, this is a relevant feature that could be comprehended as linked to the effort regulation that the students tend to apply, aiming to comply with the assignment guidelines, but somehow, looking for a way to do the minimum required so to pass the assessment; where in some instances, it was weighted with other subjects assignments and the need of having some time for social activities afterwards.

Furthermore, there was an essential element that has been observed in the teams when setting up the goals to be achieved and the planning needed to be established for the project development, what roles were to be assumed by the team members. In earlier meetings, the students' conversations revealed how the members started to organise the group and see who was to lead the group activities, and if the group, as an entity, were to agree with what this leadership would be encompassed; nevertheless, the leading aspect was something that everyone, in both teams, has avoided to take on board, probably as a mechanism to elude any issue towards the

group dynamic and not to be seen as the smartest mind in the group, or even perceived as an arrogant (University of Minnesota Libraries Publishing, 2016).

Strategy has been a strong component across the students' project meeting, being inherently linked to how the activities to be undertaken were to lead to a possibly successful assignment completion. In the meetings, there was always a sense that anything the groups were doing had to shed some sort of yield, which was most evident in the last meetings, especially, when the deadline for the project submission was approaching, and still the groups were working towards the completion of some of the key activities.

Besides, the groups have tended to adapt their activities as the tasks were completed, based on what they might have known, or heard what other groups that were attending the same subject had carried out. In addition, adaptation has been observed in strong conjunction when a strategy was devised, and particularly, when other subjects assignments needed to be addressed and their submission dates were closer to each other; hence, the groups have tended to weight the amount of effort that was to be put towards certain tasks or activities, and what impact could have over the scores according to what had been set out in the marking criteria.

As a result, when trying to establish a distinction between adaptation and strategy, Järvellä and Hadwin's (2013) model posed a challenge, creating a precise limitation for the data corpus exploration and explanation of the phenomena happening in the context of teamwork.

Additionally, Järvellä and Hadwin's (2013) model does not describe the data in a project group context as it was expected, or said in other words, the data corpus that has been gathered for this research does not fit in the model. As such, the need of looking at the data afresh, using different 'lenses' from a shared-regulated learning point of view, created the imperative requirement of a much deeper data exploration, that could lead to the conceptualisation of model that was the reflection of the data corpus itself, the interactions and transactions happening in the context of groups of chemical and process engineering students, dealing with a concept-project assignment, and that could explain succinctly what the students' utterances were telling.

6.1.4 Perspective and elements components

As presented in **Chapter 4**, the research model has incorporated elements of shared regulation found in the literature, and that have been identified across the data corpus. These elements have been present across the students interactions; however, when taking as a reference some examples that have been reported in the literature (see tables 2.2 and 2.3), as regulatory instances, it was realised that there had been a tendency to classify certain regulatory occurrences as self-regulation, co-regulation, and shared regulation through the allocation of the pronouns *I*, *you*, and *we*, respectively, as if they were directly linked to the three forms of regulation.

Nevertheless, while observing and discussing the students' interactions, the pronouns allocation has not been a straightforward process, where for instance, the use of the pronoun '*you*' not necessarily was directly connected to a certain form of co-regulation, as it has been described by Järvelä and Hadwin's (2013) and Schoor's (2018) works, but to a different form of shared regulation.

Consequently, there have been cases where, when looking at the utterances, they seemed to be showing up some sort of co-regulation, but the context says otherwise; for instance, cases where the use of the pronoun '*you*' was referring to the whole group, avoiding addressing a specific member but to the group as an entity, being this a form of implicit shared regulation. Therefore, it is not possible to entirely disentangle co-regulation from shared regulation of learning, as they both require interaction among participants in the context of group work, but it is important to be able to distinguish between their manifestation in the data.

Additionally, the previously singularity has been seen in both focus groups, where team members, for example, when presenting their ideas or proposing a method, they use phrases such as, '*why would you take commercial risks like what do you think of that meant 'cos in my understanding was*', '*so like you know that happens repeatedly'*, '*my plan for tonight is you see like if I can find a lot better data in general knowledge*', instead of being directed to a certain peer, they use the '*you*' pronoun implicitly, avoiding to point out any responsibility, or assigning a task to someone.

Furthermore, the previously mentioned aspect could have been thought to be exclusive to a particular group but that was recurring to both; thus, it could be said that by avoiding the use of a more direct pronouns use, probably, team members were

essentially looking for any feedback, or someone to say something such as the following utterances, '*I was looking through that*', '*you're right let's do it in that way*', or '*I'll do it*', and even, opposing to what someone has said with phrases such as, '*yeah a thousand tons is like not what we are looking*', to mention some examples from the data corpus, where there has been a direct interaction, avoiding any subtle messages.

On the one hand, this is totally different to certain instances during the project meetings, where students have been explicit about what has to be executed and how should be approached, expressing their ideas freely and directly, with phrases such as, '*unless unless we assume that again the the pressured air and the ammonia we're putting in*' and '*I think we are doing it deliberately right is this it's kind of short we've not got a lot of time* which', addressing the group and putting into context their points and positions regarding specific decisions, that might certainly involve the whole team.

But on the other hand, there were some cases, where they were directed to specific team members, for example, '*'cos it it it makes your argument better than saying we're going to take 365 000 tons'*, being explicit about someone's stance, voicing their position and directly addressing an issue to better structure their strategy towards an activity. Instances that could be more easily identified, opposed to those where the implicitness is to be acknowledged, and their subtlety makes hard their identification in first instance, having to analyse more broadly the context of the interactions to draw their occurrence.

6.2 Shared regulation in teams

When trying to define the most prominent set of themes, there was a need to come up with a group of topics that represented those transactions related to regulatory instances, rather than generic patterns that certainly could be present in the data compendium but were not related to the core topic of this research, shared regulation.

As a result, a group of seven themes was proposed, reflecting on the elements that were linked to shared regulation in the work-group environment; however, during their conception and more precisely, the identification within the project meetings excerpts analyses, it was realised that those themes were part of two macro-themes, or main

themes, as they have been named, that grouped them up, with certain tendency to intercept, having in common some of the themes to both main themes; an aspect that has been mainly associated to the nature and singularities of the interactions occurring in the context of the project group activities and meetings.

6.2.1 Knowledge and Processes as the umbrella themes

The identification of *knowledge* and *processes* as the conjunction of two macro themes that intercept, it is one of the most relevant and significant concepts that has emerged from the analyses, where both occur at the same time, intrinsically linked to each other. As a result, the convergence of the overarching themes, and thus, the direct implication on the themes, has allowed the dissection of the extracts with finer lenses. Consequently, explaining and understanding how the teams interactions, in reality, occur, and what the practical implications of those exchanges could have over the team performance, and ultimately, the project completion.

The occurrence of knowledge as an overarching theme could be associated, mainly, to instances where the students during the project meetings have used learning mechanisms when facing the tasks, which are directly connected to the topic or specific technical aspects being discussed.

Winne and Hadwin (2008) have considered under a fictional example the occurrence of knowledge under the conditions as presented by COPES model (Winne & Hadwin, 1998), but knowledge as has been identified in a real data corpus, such as the one collected for this research, could be associated to more stages in the instances happening across the students' project meetings, and not only limited to a specific phase, for example task definition.

For instance, throughout the data analysis, it has been identified exchanges, where there have been use of prior knowledge about the problem-solving process that was being applied, which could be related to general knowledge that the students might have acquired along their academic experiences; more specific interactions, where the students have applied prior knowledge or cognitive domain one, directly related to the project tasks, for example, when discussing the material and energy balances, and the process simulation and calculation, being evident cases during the students' project meetings discussions and interactions. Also, the use of prior knowledge, but the one that has been acquired when the outcome was not the expected one, or even

when referring to their peers' experiences, which are connected to a form of knowledge about their own performance and shared-regulation of learning.

As a result, it has been seen that knowledge is a factor that is constantly present and evolves as the project meetings took place. Proof that serves to support that a phase, as it has been presented by Järvellä and Hadwin (2013), does not occur in one single stage, but on the contrary, it is an aspect that emerges as the students make use of strategically resources along the project completion; even happening at later project stages, as it has been shown in the extracts. It has been under these exchanges that knowledge as a broaden concept has served as an umbrella concept to group the themes.

Furthermore, when correlating cognitive aspects as researched by Svinicki (2004) to knowledge on learning strategies that the students have used while completing the project activities, certainly, it was clear how they have applied strategies and tactics so to complete the tasks, looking for sources of information, ask what and how other groups that were dealing with the same assignment had dealt with specifics activities, even, from peers that have attended the same subject, but were already in the subsequent academic year. Also it was evident the way the students have weighted the project tasks requirements based on their own assumptions and interpretations, trying to strategize what was the most suitable plan to put into practice.

Nevertheless, when looking into students' exchange instances that shown what knowledge they have about themselves as learners, there was an absence of interactions that could exemplify whether or not the students were competent enough to tackle an activity. Aspect that could have happened in a different setting, but it was not seen during the project meetings.

Processes, as the other main umbrella theme, has been undoubtably recognised as the students' activities and interactions were analysed in the context of the project meetings. It has been evident that it was attached to the actions that the groups as a collective entity have taken to move the activities towards the completion of the project, and that is inherently attached to any action that the team members have undertaken while completing the project assignment. An aspect that has been identified is that processes are strongly linked to instances, such as where there is a strong tendency to deploy methods and strategies that could help tackle and give an answer to the project tasks, and that is present across the stages of the project or

task cycles as it has been studied by Zimmerman (2002), happening in almost all interactions, given their intimate relationship to the achievement or generation of a tangible product, either a final product or a concept.

Ultimately, any interaction that the students have had while working on the project activities has been a process, where there was a continuous need to develop concepts, strategies, organise the activities so ideally they were progressed and completed, being the ultimately purpose of the joint work.

6.2.2 Themes for shared-regulated learning

The identification process of specific patterns that could represent the students' learning phenomena has been at the core of this research. In doing so, elements associated to knowledge and processes, as the overarching or main themes, started to shed some lights, pointing out to specific and common elements that could explain what the students were going through as they attempted to complete a concept-project assignment.

Knowledge sharing has been one of the themes umbrella that was identified during the data sessions and analyses, and probably the most common theme across the data corpus. A theme that has been seen across different stages of the students' project meetings, and associated to interactions connected to certain task definition stages, but that emphatically has been seen occurring at various moments of the meetings, taking into account that opposite to the definition of task definition proposed by Zimmerman (2000), this could happen at any point, and without following a cyclical structure.

Also, knowledge sharing is a concept that is strongly attached to the main theme knowledge, coupling aspects strongly related to cognition, or at least, naming instances, where the students have displayed and shared some forms of familiarity to the topics being discussed during the project meetings.

Furthermore, knowledge sharing occurrence has been a theme that according to the interactions of the students has played a significant role during the project meetings; it is through the continuous introduction of knowledge or information that the conversations have been kept moving on; hence, it could be said that knowledge sharing is a core theme that scaffolds and promotes shared regulation of learning through the progression of the project activities.

Coordination construction is a theme that has been identified at different stages of the project meetings, strongly associated to knowledge sharing, but not necessarily occurring one after another. Initially, it could have been thought as a theme that would be directly linked to a certain form co-regulation of learning, an aspect that has been described by Hadwin *et al.* (2018), given that coordination construction involves the participation of at least two team members; however, the occurrence of coordination construction has been identified during instances, where the groups, as an entity, have been discussing several topics related to the project activities; hence, involving more than two members in the process.

Furthermore, coordination construction instances have had a strong tendency to be identified where there has been occurrences linked to the '*we'* perspective, while the students' exchanges were happening, supporting the idea that an element coupled to shared regulation was happening. Besides, instances where the use of the '*you*' perspective have been also identified, but not as common as those related to the more explicit '*we'* perspective.

Regarding ***agreed common knowledge****, this* has been a theme with a specific association to the occurrence of coordination construction, where agreed common knowledge could be seen as the consolidation tip of the elements related to sharing information, having discussions and exchanges, and reaching common points of understanding.

Agreed common knowledge has been a theme with the particularity of being identified in instances, where the discussions and exchanges of the team members have been around essential decisions that needed the involvement of all members; hence, implying that the essence of shared regulation of learning could be seen in action, allowing the identification of either the groups' synchroneities, disparities, or event both, while the team members reached agreements around essential aspects for the project completion (Järvelä, *et al*., 2008).

Additionally, agreed common knowledge is a theme that has had a strong association with strategy, being related to the generation of factual elements that could make the project activities being progressed as the teams' project meeting have been held. Also, agreed common knowledge is a theme that has had a central role given its relevance for the consolidation of the stages of the projects, especially in instances, where the activities were interdependent for their completion.

When looking at the data corpus, an element related to a strategic component, or as it has been called in this research, ***strategy device***, was identified, students' interactions were always on a loop type, where any activity or proposal had to produce any yield or benefit, that could support the project activities, but there was the imperative need of dissecting what it implied, because as the students' project meeting were analysed, it was evident that two tendencies or branches within the strategy device were apparent, some exchanges were more content oriented while others, more task oriented. And it has been these two tendencies, the most relevant differentiating element within the strategies identified in the data corpus.

Hadwin *et al*. (2018) have studied strategy in the context of group work, but without taking into consideration the natural variations that could exist when it is displayed by the students, presenting it as a general phase that occurs as they engage in the activities; however, strategy device as a theme is in reality an umbrella term, allowing some instances to be labelled as content oriented, which is the case when the actions of the students are directly connected to the content of what the activity requires, for example, the proposal of a process to calculate the product of a chemical reaction, where a series of actions require the proposal of a plan that could help determine what the activity asks for. Also, there is the other case, when the strategies are more oriented to the completion of the tasks, and having in mind to reach a goal, without taking into account the content; instances such as when making a decision about the plant location, proposing different approaches to come up with an ideal place that could satisfy the project requirements and following the constraints associated to it.

Nevertheless, there were exchanges that given the entwined relationship, it was hardly to make the distinction whether the instance was related to a content approach or a task or goal occurrence, prompting to the realisation that the students' interactions could be more complexed in shape and form, when trying to dissect or disentangle the interactions that were taken place as the project activities were developed.

Throughout the data corpus, ***inquiry*** has been a common element during the students' project meetings, there was always a continuous presence of questions among the team member, especially when going through the project requirements and sharing information, an aspect that has played an essential function to create a sort of evaluation as described by the COPES model (Winne & Hadwin, 1998), with

the difference that in COPES, the evaluation stage is more related to a product itself than to the proposals of a method, sharing concepts and knowledge, or present a calculation, which have been the cases that have happened in the students' project meetings as the project activities were addressed by the team members.

It has been through the permanent questioning that the project activities have been aligned, or even, changed, presenting the importance of inquiring if what the teams were completing or accomplishing, in reality, was aligned, or thought to be, with what the project requirements and guidelines have set out to deliver an appropriate product.

Group operation is a theme with a strong connection to the main theme processes, and that has served to identify and understand, how the groups of students have organised the group activities and roles of the team members, but with a particularity, there has been an absence of explicit instances where the teams, as a collective, have either assigned or even taken by themselves any leadership role, and define specific roles and responsibilities related to the tasks associated to the project development. In some cases, team members have recurred to use generic questions, trying to know who was doing what or has been working on a specific task.

Also, group operation instances have been identified in specific sequences, where there has been a continuous use of the '*we*' pronoun, given a sense of unity around the tasks or decisions, a factor that Schoor (2018) has studied under the coordination concept, but without incorporating the operation of the group, where a structure of roles and responsibilities is agreed for the successful completion of the tasks, or at least, team members decide to take on board specific roles, without being directly assigned to them but in a sense, volunteered to assume.

In addition, group operation could be certainly linked to strategy device, seeing a strong connection between both themes, where the activity that the team members were doing had an implicit strategy to sort out the possible challenges that it could have posed.

The final theme of the shared regulated learning model is ***Referencing***, which has been an element, that has been a resource that the group of students have used continuously along the project meetings. Referencing instances have been strongly identified during the very first project meetings, where the students have made use of several sources of information, such as websites, books, cases from the subject,

information from other peers who were attempting the same concept project assignment, that could be seen as essential element for the progression of the tasks, providing a form of starting point as explained by Miller and Hadwin (2015), with regards to a standard that could help evaluate how aligned what they as a team have been accomplishing.

Undoubtedly, one of the most important forms of referencing during the project meetings, and probably, the strongest influence during the progression of the project activities, it has been the role of the subject lecturer; students in both focus groups were concerned of what instructions the lecturer had given to them, and specifically, what the project guidelines had set out. Both elements have served as a constant backbone throughout the project meetings, being recursive elements that students have resorted in almost all meetings, showing the importance that a form of authority and specific instructions play in the development of academic activities.

Finally, along the data sessions and data analyses, it has been identified a close relationship among the themes, where there is a certain form of interconnectivity that keeps them revolving around the shared regulation phenomena. This is an aspect that could be related to the dynamic processes related to the vivid exchanges that the groups of students have been displaying, but in particular, a phenomena that have been evident in points where important and key decisions have to be made for the project progression.

The following section will discuss an additional aspect, a form of layer that has been identified in the model, grouping up the themes in four units.

6.2.3 An in-between layer

When looking at the themes from a different perspective within the project context, an intermediate layer that sits between the main themes, *knowledge* and *processes,* has been identified; a layer that has helped cluster the themes in four categories, (1) Goals and expectations agreement – strategy device; (2) effective communication – knowledge sharing, coordination construction, and agreed common knowledge; (3) progress monitoring – group operation and inquiry; and (4) adjusting – referencing; thus, focusing on how the tactics used during the project meetings have helped progress the teams towards the completion of the activities, and what in conjunction they have entailed.

In the subsequent sections this intermediate layer will be discussed.

1. Goals and expectations agreement

Certainly, each team member has an objective in mind for the project completion, that in the medium and long term would directly impact the group dynamics. As such, this is one of the factors that potentially could influence the most the activity outcome; thus, it is important to make sure that all team members, from earlier stages, understand the goals of the project, what is expected from them, and how their own goals and expectations align to those goals that the team might agree with.

Therefore, a synchronic relationship could be established, looking to avoid a possible mismatch between personal expectations and group dynamics, which in turn, creates a framework for certain strategic devices to be used, which have been identified in the data corpus, with the intention of tackling the tasks and what the project requires as part of its feasible conception and development.

Similarly, it has been seen during the students' meetings, how there is a continuous prevalence towards sketch some strategies to achieve what has been agreed and what each team member has in his/her mind to reach it. For instance, it could be said that strategy device and its two branches, task and content, are implicit elements of the majority of transactions and interactions that have occurred along the meetings, which are directly linked to the project tasks, being a distinctive feature that somehow helps move the team members to act upon and tackle the project requirements.

2. Effective communication

Without any hesitation, communication is at the core of shared regulation within the team context. Team members need to be able to communicate openly and honestly with each other, this allows them to share their ideas, knowledge, and raise any concern they might have. Therefore, it is through active communication that coordination construction around knowledge could successfully lead to agreements about common knowledge; hence, by communicating effectively, the team, as an entity, can build trust and work together efficiently. These elements are essential to fostering open communication, which in turns could promote useful feedback among team members, especially, when it comes to products that have the potential to impact

the team performance. Ultimately, their conjunction could lead to better decision-making and the proposal of more innovative solutions to tasks, projects, or challenges.

3. Progress monitoring

When examining how the activities have been developed, the analysis of the data corpus has singed posted a close relationship with the goals and expectations; thus, once the team members have defined what they plan to achieve by the end of the project completion, it has been seen how the groups tend to define mechanisms that could be used for the group operation, what roles were to be assumed, if they were, who was to take responsibility for certain tasks, without being imposed but taken on, as it has been witnessed in the excerpts, and how it was to be reported the progress towards the project tasks, being this one more prominent during the last project meetings, as the project deadline was approaching.

As a matter of fact, there have been specific episodes within the data corpus, when team members have checked how core activities have been progressed, through the use of questions, that sometimes seemed to be generic, but that in reality were directed to do some form of control, raising questions such as '*how's the project*', being asked by one of the members in one of the groups during their the last video-recorded meetings; or this one, '*we talked about we assumed that the ammonia produced in the reaction being trapped*', which when read it by its own could be understood as a statement said by one of the members, but that in the context of the meeting, it is an implicit question that has been raised as a way to, probably, doubled-check if an information has been reported.

Furthermore, some instances have been clear about either team members saying what exactly they have been doing, for example, '*I've been doing this calculations*', or others, where they have directly asked if they were expected to cover a task that had yet to be completed, by saying, '*do you want to have it represented and the viscosity and the difference of the scarcity of the issue*', which are part of the continuous monitoring that team members have used to ensure the activities have been progressing, helping them identify any potential difficulties early on, leading to make adjustments as required.

4. Adjusting

As any activity that is undertaken by the team members, regulating the development of it, it is a natural process; and in doing so, the use of information from different sources, such as books, websites, the outcome of a process, the subject lecturer, and data heard from or comments made by peers, have been used by the team members along the project meetings to adjust the activities the groups have been doing. These modifications have been a common element during the project meetings, where sometimes, the use of certain references could imply that what someone has performed or thought might need to be adjusted to comply with a standard or an ordinary approximation, that could not have considered while doing a specific task.

In addition, there is form of implicit strategic device when the group suggest to change or redirect what they have been executing to follow a new path, that might have sounded more reasonable according to what it has been said, researched, or even in the case, where someone has carried out or reached a factual result; for example, an utterance within the students project meetings where this has been identified is, '*we might need to have an alternative I think we need to have an alternative technical routes and then say the reason for this one and then determine the catalyst for that one*', where there is a strategic component that somehow might cause the group to consider other options to tackle a technical task while dealing with complex decisions for the completion of the assignment.

What is more, there is a direct link between certain themes that shows the complexity of the interactions among the group members, a phenomenon that has been seen in some instances across the data corpus, where within the same utterance as the statements are produced by the students, for example, the first part of the intervention could be assigned a theme, and the subsequent one another one, showing the complexity and intricate relationship of the team members interactions and transactions. An aspect that is an indicative of the close coexistence of the phases as the conversations evolve along the students' project meetings.

Figure 6.2 represents how the in-between four-category layer concept can be visualised.

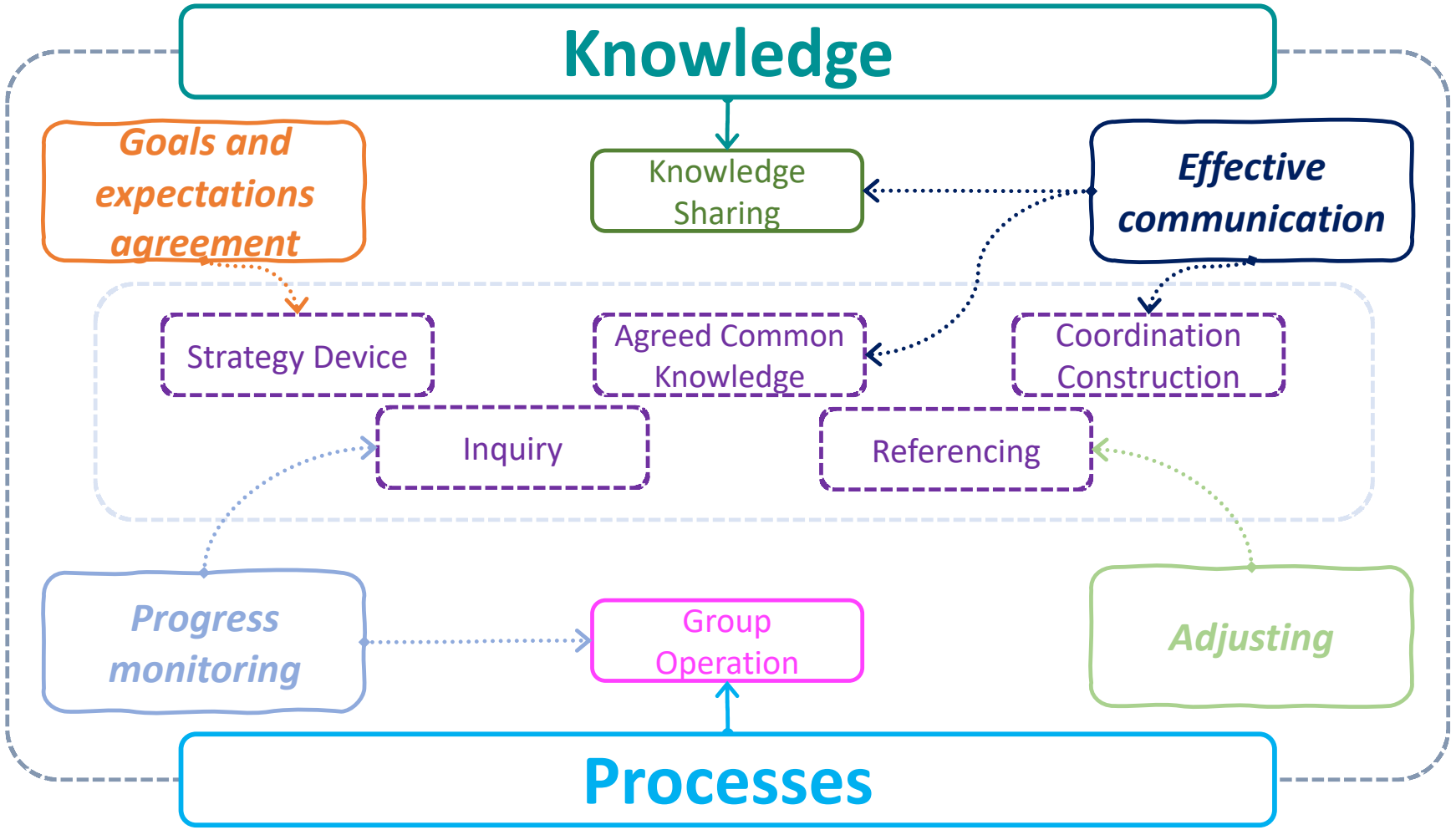


Figure 6.2. Intermediate layer within the shared-regulated learning model

At the top and bottom of figure 6.2, the two main themes, knowledge in green, and processes in blue, sit, respectively, grouping the four categories, which are located at each corner of the central arrangement; the first category, goals and expectations agreement in orange is at the upper left-hand side, connecting to strategy device through an orange dotted line.

On the opposite corner, at the right-hand side in navy blue, effective communication is located, connecting through a navy-blue dotted line to knowledge sharing – which at the same time is directly linked to the main theme knowledge, agreed common knowledge, and coordination construction. In the lower left-hand side progress monitoring can be found in light accent blue, linking through a lighter-blue line to inquiry and group operation, which connects to the main theme processes. Also, in light green adjusting is opposite positioned in the right-hand side, connecting to referencing through a green-dotted line.

In addition, a dotted lighter-blue container encloses the five themes, strategy device, agreed common knowledge, coordination construction, inquiry, and referencing, noting their particular nature being related to both main themes, knowledge and processes.

6.3 A more complex relationship

Furthermore, as it has been presented in **chapter 5**, the proposed shared-regulated learning model has been sketched in figure 5.1, displaying an intersection area between two overarching elements, *knowledge* and *processes*, as if the two macro-processes were occurring in parallel, and somehow, interconnecting and grouping the themes that have been identified in the data corpus along the data sessions; however, the juncture seems to be something else rather than a simple node.

As a consequence, through the exhaustive use of the model and much deeper analyses, it has been comprehended that the actual relationship and belonging to either one or another overarching component, could be represented as a continuum, where one moves from one part to the other without clear boundaries setting.

Figure 6.3 represents the themes and their relationship within a continuum conceptual-type idea; hence, it could be seen in figure 6.3, how the two overarching

elements, *knowledge* and *processes*, have been located in the upper and lower limits of the continuum; as such, processes has been given a northern primal location due to its particular singularity that any activity that the teams have undertaken might be subtly considered a process, since the majority of the time, the project meetings have revolved around dynamic actions that have looked for the achievement of the project completion.

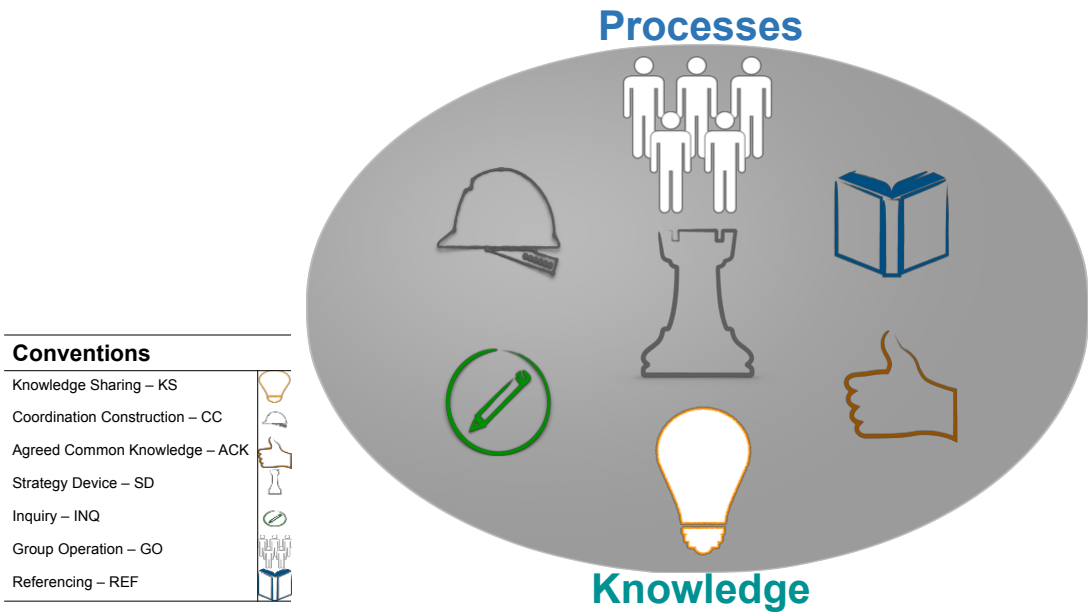


Figure 6.3. Relationship for the shared-regulated learning themes model

Furthermore, the themes have been located in figure 6.3, according to their nature, where some of them are more oriented to tasks and others, to knowledge; thus, group operation and knowledge sharing themes, known their innate type, are much closer to their respective overarching components; and the other themes, coordination construction, agreed common knowledge, strategy device, inquiry, and reference, have been positioned at the centre of the continuum, given their dual association to both, processes and knowledge.

6.4 Summary

This chapter has presented the arguments for the results, and how the data corpus has been used for the needs of the research, the different processes and stages that the research has gone through, taking as the starting point some of the existing models, which are found in the literature and that are related to shared

regulation of learning, giving an answer to the research question that this research has look to investigate, where an addition to the existing body of knowledge has been made, with the categorisation of interactions within the context of project groups work.

In addition, it has presented a more accurate research model that could genuinely represent and explain the interactions in the context of teams working in the completion of a project-concept assignment. Also, it has shown how the themes that have been identified throughout this research, can provide a more accurate description of the students teams dialogues and transactions, reflecting on the natural aspects, that in reality occur in the context of project-concept assignment team meetings.

The subsequent chapter (**7**) will present the conclusions of this research, limitations that have been encountered, implications for practice, and some recommendations for future work.

7. Conclusion

This chapter presents the general conclusions of this research. It brings the importance and relevance of this kind of study, showing the implications of the outcomes on the identification and investigation processes that have taken placed within the analysis of audio and video recording of students' project meetings. It also draws an assessment for the role of shared-regulation for the gradual improvement of intellectual skills and metacognition, which can potentially lead to autonomous learning. Furthermore, the chapter shows the impact that the proposed model could have on pragmatic pedagogies applied to the work in teams. Finally, this chapter proposes a further stage that still needs to be explored for future teaching practices.

7.1 The Impact of shared regulation in practice

As the research has advanced through the continuous transcription process and the data sessions analyses, a coding structure has been established, which has served as the basis for the proposal of a model. This shared-regulated learning model has been refined and tweaked based on the data that have been extracted from the transcripts, giving place to a model for a later analysis of the elements present. Some of the codes and themes have been defined based on current concepts, available in the literature about self-, co-, and shared regulation of learning, while others have emerged and been conceptualised from the data themselves.

As a result, the shared-regulated learning model that has been developed in this research is purely a reflect of the findings, which have emerged while analysing and observing two groups of students undertaking some activities for the completion of a concept-project assignment, providing a solid analytical framework, with a much closer structure to explaining real and natural human interactions than the existing shared-regulated conceptual models cited in the literature.

Furthermore, the model proposed in this research has helped understand and draw significant interpretations, allowing me to identify as key elements the way students

organise the different activities and tasks, deal with the different situations that could arise along their meetings, and manage their time, specifically, what refers to processes, 'transactions', and agreements in a group work environment.

Besides, the analyses have shown that the students, in these teams, have in-depth discussions and share knowledge with a strong tendency to seek consensus in the decision-making aspects of the project. At the same time, individuals look for social approval from team members. Plus, the team prefers a *laissez faire* leadership as opposed to a single leader or different leaders over a period, which could have direct implications over the students' understanding of leadership.

Kirby *et al.* (2010) have proposed a scale to measure life-long learning (LLL) considering aspects of self-regulation. They have found that, in general, deep approaches to learning lead to the development of LLL (Meyer, 2010), which would be the opposite, when a task is perceived as imposed; thus, the solely purpose of the learner is to complete the task, but with not a clear intention of acquiring any new form of knowledge, reinforcing a concept or looking for any help (Williams, *et al*., 2020). However, Kirby *et al.* (2010) have also pointed out the fact that more factors contributing to LLL (e.g., shared-regulation) need to be investigated further in terms of traits and situational aspects, aspects that have been witnessed during the students' project meetings.

In regard to whether the changes in students' level of shared regulation of learning are linked to improvement in their overall academic achievement, researchers have claimed to see an enhancement in students' performance; however, more field research needs to be executed to obtain a clearer picture of the relationship between the strategic view of the tasks applied and the outcome generated as a result of them (Zimmerman, 2008), which could potentially have implications on the effort regulation within the teamwork context.

Even though, shared regulation of learning models provide a quite specific picture of their processes, there is still much need to understand self-regulation of learning mechanisms more precisely as to identify when they are applied or performed by learners (Zimmerman, 2000). Additionally, there is a need to understand the continuum of self-regulation, co-regulation, and shared regulation of students working in teams by using data that capture students working together over extended periods of time (Järvelä & Hadwin, 2013), seeking explanation onto how the mechanisms are

used during the development of a joint task, activity, or discussions during teamwork, and what their real implications are in terms of learning progression, effective team work, and professional development. This study has contributed to precisely develop the empirical basis on which shared-regulated models can be informed.

These results have helped understand how students manage their team themselves in order to progress their team effort, and how they develop autonomy when working without the direct supervision of a lecturer or tutor. These are beneficial in considering teaching practices that can support and foster students' self-regulatory behaviours in teams.

Nonetheless, it is vital to say that the great majority of the interactions that have served to keep the conversations moving on are centred in the project assignment, being this the principal gear of the students' conversations, noting that not all the time the discussions were about the project assignment, but topics associated to other subjects, and even personal aspects, that in long term, have helped the team members continue to develop the meetings and somehow, smoothing the interactions when some hot topics related to the assignment had to be addressed.

It goes without saying, that the stages that the project meetings have gone through could have been projected as occurring one after another, as cyclic process; however, the data have told otherwise, students' interactions have shown and proofed to be more complex in every single sense, where in some instances, activities that had been assumed to be completed or discussions that thought to be over, were revisited, more questions were asked and deliberations held, exhibiting the intricacy of the students' exchanges and how several combinations of stages could arise.

7.2 Limitations

As any other research, this study has found some limitations during its development that should be recounted.

The fact that the groups and the subject that have been used for the audio- and video-recording data collection process have been located in the context of a Scottish university, within an engineering program, could limit the application of the findings of this research; for example, in a different UK university or even, country, where due to the cultural variations, the findings of this research might not be relevant or applicable.

Being this the first time that the students have been exposed and undertaken a larger problem as a project could have some downsides; they might not have a solid or enough awareness of all available tools that could be used to deal more effectively with the tasks, activities, and project challenges, which in turn, might impact how the teams perform in general terms; for example, if they were to be compared to a group of students that are more knowledgeable and familiar with a project assignment framework, some disparities could be drawn, or even, advantages be identified.

Also, another limitation that has been faced during the research execution is the audio- and video-transcription process. The transcription process has been a time consuming and exhausting activity, even more in a scenario where there has been a natural tendency of the students to speak at the same time, or interrupt while a peer is talking; making the process of isolating what one member has said more complex than already is. This limitation has been a constant during the transcription process, joint by the technical constraints of the equipment that have been used for this purpose.

Separating clearly when the teams are doing what is not easy, mainly due to the dynamic and interactive nature of social learning. There is an inherited component to students' interactions and transactions that limits the separation and distinction of what the team members are doing and aiming to in the context of learning, directly associated to aspects of human interaction.

Moreover, there has been a lack of evidence of group reflection, an aspect that has been little to no observed during the students' project meeting is group metacognition or group reflection. This is, within the regulation theories (individual and groups), always present and yet not observed explicitly in the data corpus, which makes it on its own quite surprising and interesting.

Hence, elements related to or that could have singed post that reflection was happening have not been identified during the data sessions and analyses; however, the fact that the students do not do it during the audio- and video-recorded sessions, does not mean they do not reflect on their progress and learning process. Nevertheless, there is a considerable data corpus proportion, where the metacognitive reflective process happens the least, being poorly evident in the teams, which ignites curiosity and engagement.

Additionally, although the limitations that have been encountered along this research, it is relevant to mention the novel insights that could be drawn from audio- and video-files, as they present real and natural students' interaction without major external intervention, and what their interactions could inform in the educational context.

7.3 Implications for practice

One of the elements that has been evident during the students' meeting is their constant tendency of continuously referring to the subject lecturer, which could be understood as a way of looking for a sort of approval or having someone that dictates what it must be carried out.

Although the project assignment memo has outlined what has been expected to be completed and submitted, providing enough instructions, and stating the deliverables for it, students have been in constant need of clarification. In consequence, this has been sufficed by asking their peers or even, students in upper academic years, who have already taken the subject, nor to mention that the plenary session of the class has been held, in the majority of the times, immediately after the project meetings, which could be the ideal setting to seek for the lecturer advice, without mentioning the facilitators support and also, the lecturer's office dedicated slot support.

Even though the following aspects have been provided to the students during the subject delivery:

1) introduced to the methodology, providing context to what entails and what are the learning outcomes that could be achieved, if effectively applied.
2) exposed to the benefits that such assignments under that methodology could bring to their academic and professional lives, and the constraints of it.
3) provided with tools that could be used during the project completion, especially, those related to group dynamics such task progress, how to manage disagreement and reach effective agreements, deal with social loafers, and how to receive and give effective feedback, to mention a few.
4) given directions onto how to allocate the tasks that are part of the assignment, the roles that are to be assumed, and how to keep control of the progress, indicating what to do when a member is having difficulties with the task that has been working on, how to reorganise the activities, and to whom reach out when it has been almost impossible to find a feasible route for a decision.

There is an unmistakable need to restructure and reinforce the embedded subject training for the students that are going to be faced with this type of approach, where in addition to the immediately previously listed aspects, students are also:

1) allowed the definition of their own goals so they are aligned with the group ones, seeking to create a synchronic relationship, avoiding any possible mismatch that could lead to future group nuisances.
2) given indications on to how be flexible around the activities outcomes when any adjustment or rework must be performed.
3) introduced to the implications that adaptability in the context of teamwork could have to become an effective team player, being one of the most important skills that could lead to autonomy, which ultimately might result in the development of independence within a group setting.
4) given the opportunity to reflect on the things they do not naturally reflect on by themselves, (i.e., what went well, what needs to be reoriented, what could have been done differently) every time a session is concluded.

Aspects that could improve the learning student experience in the context of teamwork, preparing the students for future academic activities that imply group work, and even, professional endeavours, where teams in companies usually work towards the successful completion of projects.

7.4 Recommendation for future work

There is a significant scope for studying the transactions and interactions that happen outside the meeting room, and even now, where the use of several means of communication are there, and clearly, have opened new research and working channels. Thus, it would be ideal to study what type of exchanges happen once the project meetings have been held and see their implications in the team dynamics, the decisions that are made, the roles that members assumed, and the constraints that limit their activities progress.

As it has been seen in this research, one element that needs further investigation is the type of leadership that is assumed in the context of teamwork, where students have tended to avoid it, which could have its downsides, e.g., diffusion of responsibility and lack of accountability, that could undermine the success of group problem-solving.

Furthermore, there is a need to further investigate how to improve shared regulation of learning in the context of teams, what strategies could be implemented to foster an effective and collaborative environment, where all members are encouraged to contribute their ideas and perspectives. In addition, it would be ideal if more academic subjects could be included, e.g., the integration of different engineering subjects and see what the impact is, when shared regulation of learning is promoted across different subjects.

Bibliography

Albertín Carbó, P., Vázquez Ahumada, M. A., Dorado Caballero, A. & Lezama Argüelles, G. A., 2016. “How do I do Discourse Analysis?” Teaching Discourse Analysis to novice researchers through a study of intimate partner gender violence among migrant women. *Qualitative Social Work,* 15(3), pp. 363-379.

Almulla, M. A., 2020. The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *SAGE Open,* 10(3), pp. 1-15.

Anderman, E. M., Sinatra, G. M. & Gray, D. L., 2012. The challenges of teaching and learning about science in the 21st century: exploring the abilities and constrains of adolescent learners. *Studies in Science Education,* 48(1), pp. 89-117.

Anderson, J. Q. & Rainie, L., 2012. *Main findings: Teens, technology, and human potential in 2020.* [Online]
Available at: https://tinyurl.com/PewResearch20
[Accessed 16 05 2021].

Assor, A., Kaplan, H. & Roth, G., 2002. Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British Journal of Educational Psychology,* Volume 72, pp. 261-278.

Asterham, C. S. & Schwarz, B. B., 2016. Argumentation for learning: Well-trodden paths and unexplored territories. *Education Psychologist,* 51(2), pp. 167-187.

Azevedo, R., 2005. Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychology,* 40(4), pp. 199-209.

Baeten, M., Struyven, K. & Dochy, F., 2013. Student-centred teaching methods: can they optimise students’ approaches to learning in professional higher education? *Studies in Educational Evaluation,* 39(1), pp. 14-22.

Baker, L., 2023. *“Double skills gap” holding back young people in the AI-era workplace, with employers highlighting a lack of emotional resilience and teamwork skills.* [Online]
Available at: https://tinyurl.com/EmpNews23
[Accessed 19 December 2023].

Bandura, A., 1986. *Social foundations of thought and action: a social cognitive theory.* Englewood Cliffs: Prentice-Hall.

Barak, M. & Levereng, A., 2016. Flexible thinking in learning: an individual differences measure for learning in technology-enhanced environments. *Computers & Education,* 1 August, Volume 99, pp. 39-52.

Barrows, H. & Kelson, A. C., 1995. *Problem-based learning in secondary education and the Problem-Based Learning Institute (Monograph 1),* Springfield, IL: Problem-Based Learning Institute.

Barrows, H. S. & Tamblyn, R. M., 1980. *Problem-based learning: an approach to medical education.* New York: Springer Publishing Company.

Bate, E., Hommes, J., Duvivier, R. & Taylor, D. C. M., 2014. Problem-based learning (PBL): getting the most out of your students – Their roles and responsibilities: AMEE Guide No. 84. *Medical Teacher,* 1 January, 36(1), pp. 1-12.

Belbin, R. M., 2010. *Management teams: why they succeed or fail.* 3rd ed. Oxford: Butterworth-Heinemann.

Bennett, B. & Szedlak, C., 2023. Aligning online and remote coaching with the digital age: novel perspectives for an emerging field of research and practice. *International Journal of Sports Science & Coaching,* 0(0), pp. 1-12.

Benson, R. & Brack, C., 2010. Where to start. In: *Online learning and assessment in Higher Education.* Oxford: Chandos Publishing, pp. 1-20.

Bernard, H. R. & Ryan, G. W., 2010. *Analyzing qualitative data: systematic approaches.* 1st Edition ed. Los Angeles: SAGE Publications.

Billett, S., 2010. Learning through practice. In: S. Billett, ed. *Learning Through Practice, Models, Traditions, Orientations and Approaches.* 1st Edition ed. London: Springer Science+Business Media, pp. 1-20.

Bloor, M., Frankland, J., Thomas, M. & Robson, K., 2001. *Focus groups in social research.* 1st Edition ed. London: SAGE Publications.

Bransford, J. D., 2000. *How people learn: brain, mind, experience, and school.* Washington(DC): National Academy Press.

Brassler, M. & Dettmers, J., 2017. How to enhance interdisciplinary competence — Interdisciplinary problem-based learning versus Interdisciplinary project-based learning. *Interdisciplinary Journal of Problem-Based Learning,* 11(2), pp. 1-14.

Braun, V. & Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3(2), pp. 77-101.

Braun, V. & Clarke, V., 2013. *Successful qualitative research: a practical guide for beginners.* 1st Edition ed. London: SAGE Publications.

Braun, V. & Clarke, V., 2019. Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health,* 8 August, 11(4), pp. 589-597.

Braun, V., Clarke, V., Hayfield, N. & Terry, G., 2019. Thematic Analysis. In: P. Liamputtong, ed. *Handbook of research methods in health social sciences.* Singapore: Springer Singapore, pp. 843-860.

Bredo, E., 1997. The social construction of learning. In: G. D. Phye, ed. *Handbook of academic learning: construction of knowledge.* San Diego(California): Academic Press, pp. 3-45.

Breitwieser, J., Neubauer, A. B., Schmiedek, F. & Brod, G., 2022. Self-regulation prompts promote the achievement of learning goals – But only briefly: uncovering hidden dynamics in the effects of a psychological intervention. *Learning and Instruction,* Volume 80, pp. 1-10.

Brophy, J. E., 1998. Classroom management as socializing students into clearly articulated roles. *Journal of Classroom Interaction,* 45(1), pp. 41-45.

Brophy, J. E., 2010. Student motivation: the teacher's perspective. In: *Motivating students to learn.* 3rd Edition ed. New York: Routledge, pp. 1-21.

Bryman, A., 2016. *Social research methods.* 5th Edition ed. Oxford: Oxford University Press.

Butler, D. L. & Winne, P. H., 1995. Feedback and self-regulated learning: a theoretical synthesis. *Review of Educational Research,* 65(3), pp. 245-281.

Byrne, D., 2021. A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Quality & Quantity,* 26 June, 56(3), pp. 1391-1412.

Capraro, M. M. & Jones, M., 2013. Interdisciplinary Stem Project-Based Learning. In: R. M. Capraro, M. M. Capraro & J. R. Morgan, eds. *STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach.* Rotterdam: SensePublishers, pp. 51-58.

Cherry, K., 2019. *Naturalistic Observation in Psychology.* [Online]
Available at: https://tinyurl.com/5dryz7sk
[Accessed 14 May 2022].

Chi, M. T. H., de Leeuw, N., Chiu, M.-H. & LaVancher, C., 1994. Eliciting self-explanations improves understanding. *Cognitive Science,* 18(3), pp. 439-477.

Clark, T., Foster, L., Sloan, L. & Bryman, A., 2021. *Bryman's social research methods.* Oxford: Oxford University Press.

Cleary, T. J. et al., 2022. Professional development in self-regulated learning: Shifts and variations in teacher outcomes and approaches to implementation. *Teaching and Teacher Education,* 1 March, Volume 111, pp. 1-12.

Cleary, Y., 2020. Fostering Communities of Inquiry and Connectivism in online technical communication programs and courses. *Journal of Technical Writing and Communication,* 51(1), pp. 11-30.

Cohen, E. G., 1994. Restructuring the classroom: conditions for productive small groups. *Review of Educational Research,* 64(1), pp. 1-35.

Cohen, L., Manion, L. & Morrison, K., 2011. *Research methods in education.* 7th Edition ed. Abingdon(Oxon): Routledge.

Corbett, F. & Spinello, E., 2020. Connectivism and leadership: harnessing a learning theory for the digital age to redefine leadership in the twenty-first century. *Heliyon,* 6(1), pp. 1-9.

Corno, L., 2008. Work habits and self-regulated learning. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 197-22.

Creswell, J. W., 2014. *Research design: qualitative, quantitative, and mixed methods apporaches.* 4th Edition ed. Los Angeles(California): SAGE Publications.

de Graaf, E. & Kolmos, A., 2003. Characteristics of problem-based learning. *International Journal of Education Engineering,* 19(5), pp. 657-662.

de Prada, E., Mareque, M. & Pino-Juste, M., 2022. Teamwork skills in higher education: is university training contributing to their mastery? *Psychology: Research and Review,* 35(1), pp. 1-13.

Deci, E. L., Nezdik, J. & Sheinman, L., 1981. Characteristics of the rewarder and intrinsic motivation of the rewardee. *Journal of Personality and Social Psychology,* 40(1), pp. 1-10.

Derry, S. J. et al., 2000. Fostering students' statistical and scientific thinking: lessons from an innovative college course. *American Educational Research Journal,* 37(3), pp. 747-773.

Detel, W., 2001. Social Constructivism. In: N. J. Smelser & P. B. Baltes, eds. *International encyclopedia of the social & behavioral sciences.* Oxford: Pergamon, pp. 14264-14267.

DiDonato, N. C., 2013. Effective self- and co-regulation in collaborative learning groups: an analysis of how students regulate problem solving of authentic interdisciplinary tasks. *Instructional Science,* 41(1), pp. 25-47.

Dochy, F., Segers, M., Van den Bossche, P. & Gijbels, D., 2003. Effects of problem-based learning: a meta-analysis. *Learning and Instruction,* October, 3(5), pp. 533-568.

Dole, S., Bloom, L. & Kowalske, K., 2016. Transforming pedagogy: changing perspectives from teacher-centered to learner-centered. *Interdisciplinary Journal of Problem-Based Learning,* 10(1), pp. 1-14.

Dolmas, D., De Grave, W., Wolfhagen, I. & Van Der Vleuten, C., 2005. Problem-based learning: future challenges for educational practice and research. *Medical Education,* 39(7), pp. 732-741.

Edgar, D. W., 2012. Learning theories and historical events affecting instructional design in education: recitation literacy toward extraction literacy practices. *SAGE Open,* 2(4), pp. 1-4.

Edström, K. & Kolmos, A., 2014. PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education,* 3 September, 39(5), pp. 539-555.

Einola, K. & Alvesson, M., 2019. The making and unmaking of teams. *Human Relations,* 72(12), pp. 1891-1919.

Ellington, J. K. & Dierdorff, E. C., 2013. Individual learning in team training: self-regulation and team context effects. *Small Group Research,* 45(1), pp. 37-67.

English, M. C. & Kitsantas, A., 2013. Supporting student self-regulated learning in problem- and project-based learning. *Interdisciplinary Journal of Problem-Based Learning,* 7(2), pp. 128-150.

Erkens, G., Prangsma, M. & Jaspers, J., 2006. Planning and coordinating activities in collaborative learning. In: A. M. O'Donnell, C. E. Hmelo-Silver & G. Erkens, eds. *Collaborative learning, reasoning, and technology.* Mahwah: Lawrance Erlbaum Associates, Inc., pp. 233-263.

Ertmer, P. A. & Newby, T. J., 2013. Behaviorism, Cognitivism, Constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly,* 26(2), pp. 43-71.

Evensen, D., 2000. Observing self-directed learners in a problem-based learning context: two case studies. In: D. Evensen & C. E. Hmelo-Silver, eds. *Problem-based learning: a research perspective on learning interactions.* Mahwah: Routledge, pp. 263-298.

Fabregas-Janeiro, M. G. & Gaeta-Gonzalez, M. L., 2015. Developing students' autonomy and self-regulation through a co-teaching research methods experience. *Contemporary Issues in Education Research,* 8(1), pp. 25-32.

Fereday, J. & Muir-Cochrane, E., 2006. Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods,* 1 March, 5(1), pp. 80-92.

Fernandes, S. R. G., 2014. Preparing graduates for professional practice: findings from a case study of project-based learning (PBL). *Procedia - Social and Behavioral Sciences,* 22 August, Volume 139, pp. 219-226.

Flick, U., 2018. Using naturally occurring data: conversation, discourse and hermeneutic analysis. In: *An introduction to qualitative research.* 6th Edition ed. Los Angeles: SAGE Publications, pp. 494-518.

Forman, J. & Damschroder, L., 2007. Qualitative Content Analysis. In: L. Jacoby & L. A. Siminoff, eds. *Empirical methods for bioethics: a primer.* Bingley: Elsevier, pp. 39-62.

Fredricks, J. A. & Eccles, J. S., 2002. Children's competence and value beliefs from childhood through adolescence: growth trajectories in two male sex-typed domains. *Developmental Psychology,* 38(4), pp. 519-533.

Friesen, N. & Anderson, T., 2004. Interaction for lifelong learning. *British Journal of Educational Technology,* 35(6), pp. 679-687.

Froehle, K. et al., 2022. Understanding lifelong learning and skills development: lessons learned from practicing civil engineers. *Journal of Civil Engineering Education,* 148(4), pp. 1-14.

Fryer, L. K. & Vermunt, J. D., 2018. Regulating approaches to learning: testing learning strategy convergences across a year at university. *British Journal of Educational Psychology,* 88(1), pp. 21-41.

Gauvain, M., 2020. Vygotsky's sociocultural theory. In: J. B. Benson, ed. *Encyclopedia of infant and early childhood development.* 2nd Edition ed. Oxford: Elsevier, pp. 446-454.

Gijbels, D., Dochy, F., Van den Bossche, P. & Segers, M., 2005. Effects of problem-based learning: a meta-analysis from the angle of assessment. *Review of Educational Research,* 75(1), pp. 27-61.

Golightly, A. & Raath, S., 2015. Problem-based learning to foster deep learning in preservice geography teacher education. *Journal of Geography,* 4 March, 114(2), pp. 58-68.

Graham, R., 2010. *UK Approaches to Engineering Project-Based Learning,* London: R. H. Graham Consulting.

Graham, S., Harris, K. R. & MacArthur, C., 2018. Self-regulation and writing. In: D. Schunk & J. A. Greene, eds. *Handbook of self-regulation of learning and performance.* New York: Routledge, pp. 138-152.

Grant, M. M., 2011. Learning, beliefs, and products: students' perspectives with project-based learning. *Interdisciplinary Journal of Problem-Based Learning,* 27 September, 5(2), pp. 1-33.

Gray, D. E. & Jensen, E. A., 2022. Analysing and presenting qualitative data. In: *Doing research in the real world.* 978-1-5297-4243-5 ed. London: SAGE Publications, pp. 749-778.

Greene, J. A. & Azevedo, R., 2007. A theoretical review of Winne and Hadwin's Model of self-regulated learning: new perspectives and directions. *Review of Educational Research,* 77(3), pp. 334-372.

Greeno, J. G., 2006. Learning in activity. In: R. K. Sawyer, ed. *The Cambridge handbook of the learning sciences.* Cambridge: Cambridge University Press, pp. 79-96.

Gross, J. J., 2015. Emotion regulation: current status and future prospects. *Psychological Inquiry,* 2 January, 26(1), pp. 1-26.

Guo, P., Saab, N., Post, L. S. & Admiraal, W., 2020. A review of project-based learning in higher education: student outcomes and measures. *International Journal of Educational Research,* Volume 102, pp. 1-13.

Hadwin, A. F., Järvelä, S. & Miller, M., 2011. Self-Regulated, co-regulated, and socially-shared regulation of learning. In: B. J. Zimmerman & D. H. Schunk, eds.

Handbook of self-regulation of learning and performance. New York: Routledge, pp. 65-84.

Hadwin, A. F. & Oshige, M., 2011. Self-regulation, co-regulation, and socially-shared regulation: exploring perspectives of social in self-regulated learning theory. *Teachers College Record,* 113(2), pp. 240-264.

Hadwin, A., Järvellä, S. & Miller, M., 2018. Self-regulation, co-regulation, and shared regulation in collaborative learning environments. In: D. H. Schunk & J. A. Green, eds. *Handbook of self-regulation of learning and performance.* 2nd Edition ed. New York: Routledge, pp. 83-107.

Haleem, A., Javaid, M., Qadri, M. A. & Suman, R., 2022. Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers,* pp. 275-285.

Harris, G., 2013. A continuous-learning process that updates and enhances planning scenarios. *Strategy & Leadership,* 41(3), pp. 42-50.

Harris, K. R., Graham, S., Brindle, M. & Sandmel, K., 2009. Metacognition and children's writing. In: D. J. Hacker, J. Dunlosky & A. C. Graesser, eds. *Handbook of metacognition in education.* 1st Edition ed. New York: Routledge, pp. 131-153.

Hartson, R. & Pyla, P. S., 2012. Contextual Inquiry: eliciting work activity data. In: R. Hartson & P. S. Pyla, eds. *The UX Book.* Boston: Morgan Kaufmann, pp. 81-127.

Heddy, B. C., Danielson, R. W., Sinatra, G. M. & Graham, J., 2017. Modifying knowledge, emotions, and attitudes about genetically modified foods. *Journal of Experimental Education,* 85(3), pp. 513-533.

Helle, L., Tynjälä, P. & Olkinuora, E., 2006. Project-based learning in post-secondary education: theory, practice and rubber sling shots. *Higher Education,* 51(2), pp. 287-314.

Hendry, G., Wiggins, S. & Anderson, T., 2015. *"That's me being stupid": Using discursive psychology to analyse self-deprecating humour as a means of constructing group cohesion in PBL.* Aalborg, Aalborg University Press, pp. 70-82.

Hmelo, C. E., 1998. Problem-based learning: effects on the early acquisition of cognitive skill in medicine. *Journal of the Learning Science,* 7(2), pp. 172-208.

Hmelo-Silver, C., 2002. *Collaborative ways of knowing: issues in facilitation.* Boulder, Routledge, pp. 199-208.

Hmelo-Silver, C. E., 2004. Problem-based learning: what and how do students learn? *Educational Psychology Review,* 16(3), pp. 235-266.

Hoekstra, A., 2008. Vibrant student voices: exploring effects of the use of clickers in large college courses. *Learning, Media and Technology,* 33(4), pp. 329-341.

Hsieh, H.-F. & Shannon, S. E., 2005. Three approaches to qualitative content analysis. *Qualitative Health Research,* 15(9), pp. 1277-1288.

Hung, W., Moallem, M. & Dabbagh, N., 2019. Social foundations of problem-based learning. In: M. Moallem, W. Hung & N. Dabbagh, eds. *The Wiley handbook of problem-based learning.* Hoboken: John Wiley & Sons, pp. 51-79.

Hurme, T.-R., Merenluoto, K. & Järvelä, S., 2009. Socially shared metacognition of pre-service primary teachers in a computer-supported mathematics course and their feelings of task difficulty: a case study. *Educational Research and Evaluation,* 15(1), pp. 503-524.

Järvelä, S. & Hadwin, A. F., 2013. New frontiers: regulating learning in CSCL. *Educational Psychologist,* 48(1), pp. 25-39.

Järvelä, S., Järvenoja, H., Malmberg, J. & Hadwin, A. F., 2013. Exploring socially shared regulation in the context of collaboration. *Journal of Cognitive Education and Psychology,* 12(3), pp. 267-286.

Järvelä, S., Järvenoja, H. & Veermans, M., 2008. Understanding the dynamics of motivation in socially shared learning. *International Journal of Educational Research,* 47(2), pp. 122-135.

Järvelä, S., Malmberg, J., Koivuniemi & Marika, 2016. Recognizing socially shared regulation by using the temporal sequences of online chat and logs in CSCL. *Learning and Instruction,* Volume 42, pp. 1-11.

Järvinen, M. & Meyer-Mik, N., 2020. Analysing qualitative data in social science. In: M. Järvinen & N. Meyer-Mik, eds. *Qualitative analysis: eight approaches for the social sciences.* London: SAGE Publications, pp. 1-28.

Jackson, P., 2010. From function to use. In: R. Rikowski, ed. *Web 2.0 knowledge technologies and the enterprise: smarter, lighter and cheaper.* Oxford: Chandos Publishing, pp. 155-196.

Jacobs, J. E. et al., 2002. Changes in children's self-competence and values: gender and domain differences across grades one through twelve. *Child Development,* 73(2), pp. 509-527.

Jaeger, M. & Adair, D., 2018. Transitioning from diploma to degree – Impact on engineering students' self-efficacy, expectancies, values and self-regulation. *European Journal of Engineering Education,* 3 September, 43(5), pp. 771-787.

Jaramillo, J. A., 1996. Vygotsky's sociocultural theory and contributions to the development of constructivist curricula. *Education,* 117(1), p. 133-140.

Jonassen, D., 2011. Supporting problem solving in PBL. *Interdisciplinary Journal of Problem-Based Learning,* 27 September, 5(2), pp. 95-119.

Jonassen, D. H., 1997. Instructional design models for well-structured and iII-structured problem-solving learning outcomes. *Educational Technology Research and Development,* 1 March, 45(1), pp. 65-94.

Jonassen, D. H. & Hung, W., 2008. All problems are not equal: implications for problem-based learning. *Interdisciplinary Journal of Problem-Based Learning,* 13 October, 2(2), pp. 6-28.

Jordan, A., Carlile, O. & Stack, A., 2008. Constructivism. In: *Approaches to learning: a guide for teachers.* Maidenhead(Berkshire): McGraw-Hill Education, pp. 55-67.

Jordan, B. & Henderson, A., 1995. Interaction Analysis: foundation and practice. *The Journal of the Learning Sciences,* 4(1), pp. 39-103.

Jozefowiez, J. & Staddon, J. E. R., 2008. Operant Behavior. In: J. H. Byrne, ed. *Learning and memory: a comprehensive reference.* Oxford: Academic Press, pp. 75-101.

Kalantzis, M. & Cope, B., 2012. The nature of learning. In: *New learning: elements of a science of education.* 2nd Edition ed. Port Melbourne(Victoria): Cambridge University Press, pp. 197-216.

Kawabata, M., Mallett, C. J. & Jackson, S. A., 2008. The flow state scale-2 and dispositional flow scale-2: examination of factorial validity and reliability for Japanese adults. *Psychology of Sport and Exercise,* 9(4), pp. 465-485.

Kempler, T. M. & Linnenbrink-Garcia, L., 2007. *Exploring self-regulation in group contexts.* New Brunswick, International Society of the Learning Sciences, pp. 357-360.

Kincheloe, J. L., 2005. *Critical constructivism primer.* New York: Peter Lang Publishing.

Kirby, J. R., Knapper, C., Lamon, P. & Egnatoff, W. J., 2010. Development of a scale to measure lifelong learning. *International Journal of Lifelong Education,* 29(3), pp. 291-302.

Kirschner, P. A. & Hendrick, C., 2020. The culture of learning. In: *How learning happens.* 1st ed. Abingdon(Oxon): Routledge, pp. 231-240.

Kjersdam, F. & Enemark, S., 1994. *The Aalborg experiment: project innovation in university education.* Aalborg: Faculty of Technology and Science, Aalborg University.

Kokotsaki, D., Menzies, V. & Wiggins, A., 2016. Project-based learning: a review of the literature. *Improving Schools,* 19(3), pp. 267-277.

Kolmos, A., 1996. Reflections on project Work and problem-based learning. *European Journal of Engineering Education,* 21(2), pp. 141-148.

Kolmos, A., 2017. PBL curriculum strategies. In: A. Guerra, R. Ulseth & A. Kolmos, eds. *PBL in engineering education: international perspectives on curriculum change.* Rotterdam: SensePublishers, pp. 1-12.

Kolmos, A. & de Graaff, E., 2014. Problem-based and project-based learning in engineering education. In: A. Johri & B. M. Olds, eds. *Cambridge Handbook of engineering education research.* 1st Edition ed. New York: Cambridge University Press, pp. 141-160.

Laal, M. & Salamati, P., 2012. Lifelong learning: why do we need it? *Procedia - Social and Behavioral Sciences,* 1 January, Volume 31, pp. 399-403.

Lam, D. O. B., 2009. Impact of problem-based learning on social work students: growth and limits. *The British Journal of Social Work,* 39(8), pp. 1499-1517.

Lapek, J., 2018. Promoting 21st century skills in problem-based learning environments. In: J. G. Wells, ed. *Research Monograph Series.* Blacksburg(Virginia): CTETE, pp. 66-85.

Lazonder, A. W. & Harmsen, R., 2016. Meta-analysis of inquiry-based learning: effects of guidance. *Review of Educational Research,* September, 86(3), pp. 681-718.

Leary, H., Walker, A., Lefler, M. & Kuo, Y.-C., 2019. Self-directed learning in problem-based learning. In: M. Moallem, W. Hung & N. Dabbagh, eds. *The Wiley handbook of problem-based learning.* Medoford: Jonh Wiley & Sons, pp. 181-198.

Lee, C. B., Hanham, J. & Leppink, J., 2018. *Instructional design principles for high-stakes problem-solving environments.* 1st Edition ed. Singapore: Springer Singapore.

Lens, W. & Vansteenkiste, M., 2008. Promoting self-regulated learning. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 141-168.

Lewis, J., Ritchie, J., Ormston, R. & Morrell, G., 2014. Generalising from qualitative research. In: J. Ritchie, J. Lewis, C. McNaughton Nicholls & R. Ormston, eds. *Qualitative research practice: a guide for social sciences students and researchers.* 2nd Edition ed. Los Angeles: SAGE Publications, pp. 347-366.

Limberg, D. et al., 2021. School counselor and teacher collaboration to enhance students' career development using Project-Based Learning. *Professional School Counseling,* 24(1b), pp. 1-11.

Logan, C. R., DiCintio, M. J., Cox, K. E. & Turner, J. C., 1995. *Teacher and student perceptions of classroom practice.* Ellenville, North-eastern Educational Research Association.

Lopez, E. J. et al., 2013. Self-regulated learning study strategies and academic performance in undergraduate organic chemistry: an investigation examining ethnically diverse students. *Journal of Research in Science Teaching,* 50(6), pp. 660-676.

Lovgren, R. H. & Racer, M. J., 2000. Group dynamics in projects: don't forget the social aspects. *Journal of Professional Issues in Engineering Education and Practice,* 126(4), pp. 156-165.

Lowrance, W. W., 2012. Privacy, confidentiality, safeguards. In: *Privacy, Confidentiality, and Health Research.* 1st ed. Cambridge: Cambridge University Press, pp. 29-34.

Lucas, B., Hanson, J. & Claxton, G., 2014. *Thinking like an engineer. Implications for the education system,* London: Royal Academy of Engineering.

Mabley, S., 2020. *A qualitative analysis of students' naturalistic learning processes during their first experience in problem-based learning,* Glasgow: University of Strathclyde.

Macaskill, A. & Denovan, A., 2013. Developing autonomous learning in first-year university students using perspectives from positive psychology. *Studies in Higher Education,* 38(1), pp. 124-142.

Macaskill, A. & Taylor, E., 2010. The development of a brief measure of learner autonomy in university students. *Studies in Higher Education,* 35(3), pp. 351-359.

Macnaghten, P. & Myers, G., 2013. Focus groups. In: C. Seale, G. Govo, J. F. Gubrium & D. Silverman, eds. *Qualitative research practice.* London: SAGE Publications, pp. 65-79.

Malmberg, J., Järvelä, S., Järvenoja, H. & Panadero, E., 2015. Promoting socially shared regulation of learning in CSCL: progress of socially shared regulation among high- and low-performing groups. *Computers in Human Behavior,* 1 November, Volume 52, pp. 562-572.

Markula, A. & Aksela, M., 2022. The key characteristics of project-based learning: how teachers implement projects in K-12 science education. *Disciplinary and Interdisciplinary Science Education Research,* 6 January, 4(1), pp. 1-17.

Marton, F. & Booth, S., 1997. *Learning and awareness.* Mahwah(New Jersey): Lawrence Erlbaum Associates.

Matheson, R. & Haas, B., 2010. Exploring the foundations for problem-based learning. In: T. Clouston, et al. eds. *Problem-Based Learning in Health and Social Care.* Hoboken(New Jersey): Wiley-Blackwell, pp. 9-24.

Matusov, E., 2001. Vygotskij's theory of human development and new approaches to education. In: N. J. Smelser & P. B. Baltes, eds. *International encyclopedia of the social & behavioral sciences.* Oxford: Pergamon, pp. 16339-16343.

Mayring, P., 2000. Qualitative Content Analysis [28 paragraphs]. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research,* 1(2), pp. 1-10.

McQuade, R. M., 2020. *Juggling institutional and social demands: a conversation analysis of engineering students' interactions in self-managed problem-based learning,* Glasgow: University of Strathclyde.

McQuade, R. M. et al., 2020. Students' strategies for managing social loafers in PBL: interactional means of dealing with unequal participation in group work. In: S. Bridges & R. Imafuku, eds. *Interactional Research into Problem-Based Learning.* West Lafayette(Indiana): Purdue University Press, pp. 275-298.

McQuade, R. M., Wiggins, S. & Ventura-Medina, E., 2017. *'Doing' disagreement without being disagreeable: how students deal with conversational norms in group work.* Salzburg, European Psychology Learning and Teaching Conference 2017.

Meece, J. & Painter, J., 2009. Gender, self-regulation, and motivation. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 339-367.

Mehl, M., Robbins, M. L. & Deters, F. G., 2012. Naturalistic observation of health-relevant social processes: the electronically activated recorder methodology in psychosomatics. *Psychosomatic Medicine,* May, 74(4), pp. 410-417.

Mensah, E., 2015. Exploring constructivist perspectives in the college classroom. *SAGE Open,* 5(3), pp. 1-14.

Meyer, J. H. F., 2010. Helping our students: learning, metalearning, and threshold concepts. In: J. Christensen Hughes & J. Mighty, eds. *Taking stock: research on teaching and learning in higher education.* 1st Edition ed. Montreal(Ontario): McGill-Queen's University, pp. 191-213.

Middleton, M. J. & Midgley, C., 2002. Beyond motivation: middle school students' perceptions of press for understanding in mathematics. *Contemporary Educational Psychology,* 1 July, 27(3), pp. 373-391.

Miles, M. B., Huberman, A. M. & Saldaña, J., 2014. *Qualitative Data Analysis: a methods sourcebook.* 3rd ed. Los Angeles(California): SAGE Publications.

Miller, B., 2019. *16 advantages and disadvantages of naturalistic observation research in psychology.* [Online]
Available at: https://tinyurl.com/MillerB2019
[Accessed 15 May 2022].

Miller, M. & Hadwin, A., 2015. Scripting and awareness tools for regulating collaborative learning: changing the landscape of support in CSCL. *Computers in Human Behavior,* 52(1), pp. 573-588.

Mimiaga, M. J. et al., 2009. Individual interventions. In: K. H. Mayer & H. F. Pizer, eds. *HIV Prevention.* San Diego(California): Academic Press, pp. 203-239.

Mohd-Yusof, K., 2017. Sustaining change for PBL at the course level: taking the scholarly approach. In: A. Guerra, R. Ulseth & A. Kolmos, eds. *PBL in Engineering Education.* 1st Edition ed. Rotterdam: Sense Publishers, pp. 13-32.

Morgan, J. R., Moon, A. M. & Barroso, L. R., 2013. Engineering better projects. In: *STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach.* Rotterdam: Sense Publishers, pp. 29-39.

Morgeson, F. P., Reider, M. H. & Campion, M. A., 2005. Selecting individuals in team settings: the importance of social skills, personality characteristics, and teamwork knowledge. *Personnel Psychology,* 58(3), pp. 583-611.

Muskett, T., 2019. Cognitivism. In: J. S. Damico & M. J. Ball, eds. *The SAGE Encyclopedia of human communication sciences and disorders.* Thousand Oaks(California): SAGE Publications.

Neely, J. G. et al., 2006. Practical guides to efficient life-long learning. *Otolaryngology–Head and Neck Surgery,* 135(4), pp. 608-615.

Nelson, T. O. & Narens, L., 1994. Why investigate metacognition? In: J. Metcalfe & A. P. Shimamura, eds. *Metacognition: knowing about knowing.* Cambridge: MIT Press, pp. 1-25.

Newell, C. & Bain, A., 2018. *Team-based collaboration in higher education learning and teaching.* 1st Edition ed. Singapore: Springer Singapore.

Northwood, M. D., Northwood, D. O. & Northwood, M. G., 2003. Problem-based learning (PBL): from the health sciences to engineering to value-added in the workplace. *Global Journal of Engineering Education,* 7(2), pp. 157-164.

Oldfather, P., West, J., White, J. & Wilmarth, J., 1999. *Learning through children's eyes: social constructivism and the desire to learn.* 1st Edition ed. Washington(DC): American Psychological Association.

Oleson, A. & Hora, M. T., 2014. Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices. *Higher Education,* 23 October, 68(1), pp. 29-45.

Pekrun, R. & Stephens, E. J., 2012. Academic emotions. In: K. R. Harris, et al. eds. *APA handbooks in psychology.* Washington: American Psychological Association, pp. 3-31.

Peräkylä, A., 2011. Validity in research on naturally occurring social interaction. In: D. Silverman, ed. *Qualitative Research.* London: SAGE Publications, pp. 365-382.

Perels, F., Gürtler, T. & Schmitz, B., 2005. Training of self-regulatory and problem-solving competence. *Learning and Instruction,* 1 April, 15(2), pp. 123-139.

Phillips, D. C. & Soltis, J. F., 2009. *Perspectives on learning.* 5th Edition ed. New York: Teachers College.

Phye, G. D., 1997. Classroom learning, looking ahead. En: G. D. Phye, ed. *Handbook of academic learning: construction of knowledge.* San Diego(California): Academic Press, pp. 593-602.

Pintrich, P. R. & de Groot, E. V., 1990. Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology,* 82(1), pp. 33-40.

Potter, J., 2008. Naturalistic data. In: L. M. Given, ed. *The SAGE encyclopaedia of qualitative research methods.* Thousand Oaks: SAGE Publications, Inc, pp. 546-548.

Potter, J., 2011. Naturalistic data. In: V. Jupp, ed. *The SAGE dictionary of social research methods.* London: SAGE Publications, pp. 192-193.

Potter, J. & Shaw, C., 2017. The virtues of naturalistic data. In: U. Flick, ed. *The SAGE handbook of qualitative data collection.* 1st ed. London: SAGE Publications, pp. 182-199.

Powers, P., 2001. The theoretical foundations of discourse analysis. In: *The methodology of discourse analysis.* Sudbury: Jones and Bartlett Publishers, pp. 1-20.

Pritchard, A., 2009. *Ways of learning: learning theories and learning styles in the classroom.* 2nd Edition ed. Abingdon(Oxon): Routledge.

Pritchard, A. & Woollard, J., 2010. *Psychology for the classroom: constructivism and social learning.* 1st Edition ed. London: Routledge.

Pryor, C. R. & Kang, R., 2013. Project-Based Learning. In: R. M. Capraro, M. M. Capraro & J. R. Morgan, eds. *STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach.* Rotterdam: SensePublishers, pp. 129-138.

Reeve, J., Ryan, R., Deci, E. L. & Jang, H., 2008. Understanding and promoting autonomous self-regulation. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 223-243.

Reimann, P. & Bannert, M., 2018. Self-regulation of learning and performance in computer-supported collaborative learning environments. In: D. H. Schunk & J. Greene, eds. *Handbook of self-regulation of learning and performance.* 2nd Edition ed. New York: Routledge, pp. 285-3003.

Renda, G. & Kuys, B., 2015. Connectivism as a pedagogical model within industrial design education. *Procedia Technology,* 1 January, 20(1), pp. 15-19.

Riso, L. P. & McBride, C., 2007. Introduction: a return to a focus on cognitive schemas. In: L. P. Riso, P. L. du Toit, D. J. Stein & J. E. Young, eds. *Cognitive schemas and core beliefs in psychological problems: a scientist-practitioner guide.* Washington(DC): American Psychological Association, pp. 3-9.

Ritchie, J. & Lewis, J., 2003. *Qualitative research practice: a guide for social science students and researchers.* 1st ed. London: SAGE Publications.

Roeser, R. W., Midgley, C. & Urdan, T. C., 1996. Perceptions of the school psychological environment and early adolescents' psychological and behavioural functioning in school: the mediating role of goals and belonging. *Journal of Educational Psychology,* 88(3), pp. 408-422.

Rogat, T. K. & Adams-Wiggins, K. R., 2014. Other-regulation in collaborative groups: implications for regulation quality. *Instructional Science,* 42(6), pp. 879-904.

Rooij, S. W. v., 2009. Scaffolding project-based learning with the project management body of knowledge (PMBOK®). *Computers & Education,* 1 January, 52(1), pp. 210-219.

Roth, W.-M., 1999. Authentic school science: intellectual traditions. In: R. McCormick & C. F. Paechter, eds. *Learning and knowledge.* London: Paul Chapman Publishing, pp. 6-20.

Ruiz-Primo, M. A. & Shavelson, R. J., 1996. Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching,* 33(6), pp. 569-600.

Ryan, R. M. & Deci, E. L., 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist,* 55(1), pp. 68-78.

Ryan, R. M. & Deci, E. L., 2009. Promoting self-determined school engagement. In: K. R. Wentzel & A. Wigfield, eds. *Handbook of motivation at school.* New York: Routledge, pp. 170-195.

Säljö, R., 2010. Learning in a sociocultural perspective. In: P. Peterson, E. Baker & B. McGaw, eds. *International encyclopedia of education.* 3rd Edition ed. Oxford: Elsevier, pp. 498-502.

Saab, N., 2012. Team regulation, regulation of social activities or co-regulation: Different labels for effective regulation of learning in CSCL. *Metacognition Learning,* 7(1), pp. 1-6.

Saldaña, J., 2021. *The coding manual for qualitative researchers.* 4th ed. Los Angeles: SAGE Publications.

Santangelo, T., Harris, K. & Graham, S., 2016. Self-regulation and writing: an overview and meta-analysis. In: C. A. MacArthur, S. Graham & J. Fitzgerald, eds. *Handbook of writing research.* 2nd Edition ed. New York: Guilford, pp. 174-193.

Savery, J. R., 2019. Comparative pedagogical models of problem-based learning. In: M. H. W. D. N. Moallem, ed. *The Wiley handbook of problem-based learning.* Medford: John Wiley & Sons, Inc., pp. 81-104.

Savin-Baden, M., 2003. *Facilitating problem-based learning: illuminating perspectives.* Maidenhead: Society for Research into Higher Education & Open University Press.

Schmidt, H. G. & Moust, J. H. C., 2000. Factors affecting small-group tutorial learning: a review of research. In: D. H. Evensen & C. E. Hmelo, eds. *Problem-Based Learning.* 1st Edition ed. Mahwah: Lawrence Erlbaum Associates, pp. 19-52.

Schmidt, H. G., Rotgans, J. I. & Yew, E. H., 2011. The process of problem-based learning: what works and why. *Medical Education,* 45(8), pp. 792-806.

Schmidt, H. G., Rotgans, J. I. & Yew, E. H. J., 2019. Cognitive constructivist foundations of problem-based learning. In: M. Moallem, W. Hung & N. Dabbagh, eds. *The Wiley handbook of problem-based learning.* Medford(Massachusetts): John Wiley & Sons, pp. 25-50.

Schmidt, H. G., Van Der Molen, H. T., Te Winkel, W. W. R. & Wijnen, W. H. F. W., 2009. Constructivist, problem-based learning does work: a meta-analysis of curricular comparisons involving a single medical school. *Educational Psychologist,* 28 October, 44(4), pp. 227-249.

Schoor, C., 2018. CASoRL - Coding Scheme for the Analysis of Social Regulation of Learning. In: E. Brauner & M. K. M. Boos, eds. *The Cambridge handbook of group interaction analysis.* Cambridge: Cambridge University Press, pp. 528-536.

Schoor, C., Narciss, S. & Körndle, H., 2015. Regulation during cooperative and collaborative learning: a theory-based review of terms and concepts. *Educational Psychologist,* 3 April, 50(2), pp. 97-119.

Schreier, M., 2012. *Qualitative Content Analysis.* 1st Edition ed. London: SAGE Publications.

Schunk, D. & Ertmer, P. A., 2000. Self-regulation and academic learning: self-efficacy enhancing interventions. In: M. Boekaerts, P. R. Pintrich & M. Zeidner, eds. *Handbook of self-regulation.* San Diego: Academic Press, pp. 631-649.

Schunk, D. H., 2011. *Learning theories: an educational perspective.* 6th ed. Boston: Pearson.

Schunk, D. H. & Ertmer, P. A., 1999. Self-regulatory processes during computer skill acquisition: goal and self-evaluative influences. *Journal of Educational Psychology,* 991(2), pp. 251-260.

Seale, C., 2012. Validity, reliability and the quality of research. In: C. Seale, ed. *Researching society and culture.* London: SAGE Publications, pp. 528-543.

Servant-Miklos, V. F. C., Norman, G. R. & Schmidt, H. G., 2019. A short intellectual history of problem-based learning. In: M. Moallem, W. Hung & N. Dabbagh, eds. *The Wiley handbook of problem-based learning.* Medford: John Wiley & Sons, Inc., pp. 3-24.

Shuler, C. F., 2012. Comparisons in basic science learning outcomes between students in PBL and traditional dental curricula at the same dental school. In: S. Bridges, C. McGrath & T. L. Whitehill, eds. *Problem-based learning in clinical education: the next generation.* Dordrecht: Springer Netherlands, pp. 35-46.

Silverman, D., 2011. *Interpreting qualitative data: a guide to the principles of qualitative research.* 4th Edition ed. London: SAGE Publications.

Silverman, D., 2011. *Qualitative research: issues of theory, method and practice.* 3rd ed. London: SAGE Publications.

Simon, B., 1999. Why no pedagogy in England? In: J. Leach & B. Moon, eds. *Learners and pedagogy.* London: Paul Chapman Publishing, pp. 34-45.

Simons, J., Dewitte, S. & Lens, W., 2000. Wanting to have vs. wanting to be: the effect of perceived instrumentality on goal orientation. *British Journal of Psychology,* 24 December, 91(3), pp. 335-351.

Simons, K. D., Klein, J. D. & Brush, T. R., 2004. Instructional strategies utilized during the implementation of a hypermedia, problem-based learning environment: a case study. *Journal of Interactive Learning Research,* 15(3), pp. 213-233.

Sinatra, G. M. & Taasoobshirazi, G., 2018. The self-regulation of learning and conceptual change in science. In: D. H. Schunk & J. A. Greene, eds. *Handbook of self-regulation of learning and performance.* New York: Routledge, pp. 153-165.

Singh, K., Mahajan, R., Gupta, P. & Singh, T., 2018. Flipped classroom: a concept for engaging medical students in learning. *Indian Paediatrics,* 1 June, 55(6), pp. 507-512.

Stefanou, C. R., Perencevich, K. C., DiCinto, M. & Turner, J. C., 2004. Supporting autonomy in the classroom: ways teachers encourage student decision making and ownership. *Educational Psychologist,* 39(2), pp. 97-110.

Stewart, M., 2021. Understanding learning: theories and critique. In: L. Hunt & D. Chalmers, eds. *University teaching in focus: a learning-centred approach.* 2nd Edition ed. London: Routledge, pp. 3-28.

Strobel, J. & van Barneveld, A., 2009. When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-Based Learning,* 24 March, 3(1), pp. 45-58.

Succi, C. & Canovi, M., 2020. Soft skills to enhance graduate employability: comparing students and employers' perceptions. *Studies in Higher Education,* 1 September, 45(9), pp. 1834-1847.

Sutton, S., 2001. Health behavior: psychosocial theories. In: N. J. Smelser & P. B. Baltes, eds. *International encyclopedia of the social & behavioral sciences.* Oxford: Pergamon, pp. 6499-6506.

Svinicki, M. D., 2004. *Learning and motivation in the postsecondary classroom.* 1st Edition ed. San Francisco: Jossey-Bass.

Tan, J. C. L. & Chaptman, A., 2016. *Project-based learning for academically-able students: Hwa Chong Institution in Singapore.* 1st Edition ed. Rotterdam: SensePublishers Rotterdam.

Thomas, J. W., 2000. *A review of research on project-based learning.* [Online] Available at: https://tinyurl.com/ThomasJW2000
[Accessed 25 April 2019].

Toering, T. et al., 2012. Measuring self-regulation in a learning context: reliability and validity of the Self-Regulation of Learning self-Report Scale (SRL-SRS). *International Journal of Sport and Exercise Psychology,* 1 March, 10(1), pp. 24-38.

Tokuhama-Espinosa, T., 2010. *The new science of teaching and learning: using the best of mind, brain, and education science in the classroom.* New York: Teachers College Press.

Tonkiss, F., 2012. Discourse analysis. In: C. Seale, ed. *Researching society and culture.* 3rd Edition ed. London: SAGE Publications, pp. 405-423.

Treisman, U., 1992. Studying students studying calculus: a look at the lives of minority mathematics students in college. *The College Mathematics Journal,* 23(5), pp. 362-372.

Tularam, G. A. & Machisella, P., 2018. Traditional vs non-traditional teaching and learning strategies - The case of E-learning!. *International Journal for Mathematics Teaching and Learning,* 19(1), pp. 129-158.

Turner, J. C. et al., 1998. Creating contexts for involvement in mathematics. *Educational Psychology,* 90(4), pp. 730-745.

University of Minnesota Libraries Publishing, 2016. Leadership, roles, and problem solving in groups. In: U. o. M. L. Publishing, ed. *Communication in the real world.* Minneapolis: University of Minnesota Libraries Publishing, pp. 694-707.

Usher, L. E. & Schunk, D. H., 2018. Social cognitive theoretical perspective of self-regulation. In: D. H. Schunk & J. A. Greene, eds. *Handbook of self-regulation of learning and performance.* 2nd ed. New York(New York): Routledge, pp. 19-35.

Vaismoradi, M., Turune, H. & Bondas, T., 2013. Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. *Nursing and Health Sciences,* Volume 15, pp. 398-405.

VanElzakker, M. B. et al., 2014. From Pavlov to PTSD: the extinction of conditioned fear in rodents, humans, and anxiety disorders. *Neurobiology of Learning and Memory,* 113(1), pp. 3-18.

Veenman, M. V. J., 2011. Learning to self-monitor and self-regulate. In: R. E. Mayer & P. A. Alexander, eds. *Handbook of research on learning and instruction.* New York: Routledge, pp. 197-218.

Veenman, M. V. J., Kok, R. & Blöte, A. W., 2005. The relation between intellectual and metacognitive skills in early adolescence. *Instructional Science,* 33(3), pp. 193-211.

Vermetten, Y. J., Lodewijks, H. G. & Vermunt, J. D., 1999. Consistency and variability of learning strategies in different university courses. *Higher Education,* 37(1), pp. 1-21.

Walker, R. A., 2010. Sociocultural issues in motivation. In: P. Peterson, E. Baker & B. McGaw, eds. *International encyclopedia of education.* 3rd Edition ed. Oxford: Elsevier, pp. 712-717.

Wallin, P. & Adawi, T., 2018. The reflective diary as a method for the formative assessment of self-regulated learning. *European Journal of Engineering Education,* 43(4), pp. 507-521.

Warnock, J. N. & Mohammadi-Aragh, M., 2016. Case Study: Use of problem-based learning to develop students' technical and professional skills. *European Journal of Engineering Education,* 41(2), pp. 142-153.

Warr, M. & West, R. E., 2020. Bridging academic disciplines with interdisciplinary project-based learning. *The Interdisciplinary Journal of Problem-Based Learning,* 29 May, 14(1), pp. 1-22.

Watson, R. & Coulter, J., 2008. The debate over cognitivism. *Theory, Culture & Society,* 1 March, 25(2), pp. 1-17.

Wigfield, A., Hoa, L. W. & Klauda, S. L., 2008. The role of achievement values in the regulation of achievement behaviors. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 169-195.

Wiggins, S., 2017. *Discursive psychology: theory, method and applications.* 1st Edition ed. Croydon: SAGE Publications.

Wijnia, L., Loyens, S. M. M. & Rikers, R. M. J. P., 2019. The problem-based learning process. In: M. Moallem, W. Hung & N. Dabbagh, eds. *The Wiley handbook of problem-based learning.* 1st ed. Medford(Massachusetts): John Wiley & Sons, Inc, pp. 273-295.

Williams, J., Kirk, A. & Bewley, T., 2020. Health and social care professions. In: S. Marshall, ed. *A handbook for teaching and learning in higher education.* 5th Edition ed. Abingdon(Oxon): Routledge, pp. 331-343.

Winne, P. H., 1995. Inherent details in self-regulated learning. *Educational Psychologist,* 30(4), pp. 173-187.

Winne, P. H., 1996. A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences,* 8(4), pp. 327-353.

Winne, P. H., 1997. Experimenting to bootstrap self-regulated learning. *Journal of Educational Psychology,* 89(3), pp. 397-410.

Winne, P. H., 2004. Putting volition to work in education. *Teachers College Record,* Volume 106, pp. 1879-1887.

Winne, P. H., 2018. Cognition and metacognition within self-regulated learning. In: D. H. Schunk & J. A. Green, eds. *Handbook of self-regulation of learning and performance.* 2nd ed. New York(New York): Routledge, pp. 36-48.

Winne, P. H. & Hadwin, A. F., 1998. Studying as self-regulated learning. In: D. J. Hacker, J. Dunlosky & A. C. Graesser, eds. *Metacognition in educational theory and practice.* Mahwah: Lawrence Erlbaum, pp. 277-304.

Winne, P. H. & Hadwin, A. F., 2008. The weave of motivation and self-regulated learning. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 297-314.

Winne, P. H. & Jaimeson-Noel, D., 2003. Self-regulating studying by objectives for learning: students' reports compared to a model. *Contemporary Educational Psychology,* 28(3), pp. 259-276.

Winne, P. H. & Perry, N. E., 2000. Measuring self-regulated learning. In: M. Boekaersts, P. R. Pintrich & M. Zeidner, eds. *Handbook of self-regulation.* San Diego: Academic Press.

Wood, E. J., 2004. Problem-based learning: exploiting knowledge of how people learn to promote effective learning. *Bioscience Education,* 3(1), pp. 1-12.

Woods, N., 2014. *Describing discourse: a practical guide to discourse analysis.* 1st Edition ed. Abingdon(Oxon): Routledge.

Woollard, J., 2010. *Psychology for the classroom: behaviourism.* 1st Edition ed. Abingdon(Oxon): Routledge.

Zimmerman, B. J., 1990. Self-regulating academic learning and achievement: the emergence of a social cognitive perspective. *Educational Psychology Review,* 2(2), pp. 173-201.

Zimmerman, B. J., 1995. Self-regulation involves more than metacognition: a social cognitive perspective. *Education Psychologist,* 30(4), pp. 217-221.

Zimmerman, B. J., 1998. Developing self-fulfilling cycles of academic regulation: an analysis of exemplary instructional model. In: D. H. Schunk & B. J. Zimmerman, eds. *Self-regulated learning: from teaching to self-reflective practice.* New York: Guilford, pp. 1-19.

Zimmerman, B. J., 2000. Attaining self-regulation: a social cognitive perspective. In: M. Boekaerts, P. R. Pintrich & M. Zeidner, eds. *Handbook of self-regulation.* San Diego: Academic Press, pp. 13-39.

Zimmerman, B. J., 2002. Becoming a Self-Regulated Learner: An Overview. *Theory Into Practice,* 41(2), pp. 64-70.

Zimmerman, B. J., 2008. Investigating self-regulation and motivation: historical background, methodological developments, and future prospects. *American Educational Research Journal,* 45(1), pp. 166-183.

Zimmerman, B. J. & Martinez-Pons, M., 1986. Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal,* 23(4), p. 614–628.

Zimmerman, B. J. & Martinez-Pons, M., 1988. Construct validation of a strategy model of student self-regulated learning. *Educational Psychology,* 80(3), pp. 281-290.

Zimmerman, B. J. & Moylan, A. R., 2009. Self-regulation - Where metacognition and motivation intersect. In: D. J. Hacker, J. Dunlosky & A. C. Graesser, eds. *Handbook of metacognition in education.* 1st ed. New York: Routledge, pp. 299-315.

Zimmerman, B. J. & Schunk, D. H., 2009. Motivation: an essential dimension of self-regulated learning. In: D. H. Schunk & B. J. Zimmerman, eds. *Motivation and self-regulated learning: theory, research, and applications.* New York: Routledge, pp. 1-30.

Appendices

Appendix 1 – Project assignment memo

memo

KUL Engineering

To: Conceptual Design team
From: Esther Ventura-Medina
CC: Economics team, Detailed Design team,
Date: 15-Jan-18
Re: Project CD-05486007-2018 Nitric Acid Technical Proposal and Basic Engineering Design

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Dear team

We have received the information from the customer about the Nitric Acid (Technical Grade) production plant.

Your team is now tasked with producing the initial Technical Proposal. Reporting and documentation requirements are specified in Table 1. This Technical Proposal has to be presented to the customer by 6/February 2018. Consequently your presentation needs to be submitted no later than the 5/February 2018 15:00 to the filing system in order for us to have all documentation ready.

All engineering calculations are required to be checked at least by one person. Hence, each engineer in your team must check a portion of the work of the team before signing-off and submitting it.

Following the presentation of the Technical Proposal and discussion with the client on the day if the client agrees to progress the project further to Basic Engineering Design then your team will need to produce part of the initial Basic Engineering Design report.

The anticipated deadline for the completion of the BEDR is 20/March 2018 at 17:00noon. This deadline is to allow time for the project management team to put forward the whole documentation to the client before meeting with their technical team on 25/March 2018 and also before your short presentation to some representatives of the Board of directors. The presentation to the board will be take place on Tuesday 27/March 13:00-17:00. You will need to prepare this including aspects of the development and outcomes of the preliminary conceptual design on the NA process.

The deadlines in the schedule are very strict so that we can compile and organise all the design documentation for the entire Nitric Acid project in a timely manner. In summary the deadline for each stage are as follows;

memo

Reporting stage	Deadline
Technical Proposal	Presentation file submission 5/February 2018 at 15:00.
	Presentation 6/February 2018 13:00-17:00.
Basic Engineering Design Report	Report submission 20/March 17:00.
BED Presentation to Board	Presentation file submission 26/March 2018 at 17:00.
	Presentation 27/March 2018 13:00-17:00.

Reporting and documentation requirements for each stage of the project are specified in Tables 1 and 2. Other information regarding the reporting at each stage can be found in the filing system.

All engineering calculations are required to be checked. Therefore it is essential that all documentation have the relevant information completed in the title block. Make sure that you plan ahead to account for checks and changes –the information needs to be put forward to checkers ahead of deadlines and with sufficient time for corrections to be made. Also, remember to keep track of the revision number in the documents.

You can submit the work through the adequate link in our filing system. This will help in compiling the information. If you have any questions please do get in touch with me.

Kind regards,

Esther Ventura-Medina
CE- Project Manager

memo

Table 1. Technical Proposal Requirements for Nitric Acid Plant – Project CD-05486007-2018. Elements to report on presentation.

Item	Content
1-Executive Summary	Brief description of the process and summarize key advantages and competing technologies.
2-Proposal basis	• Processing objectives • Feedstocks including availability, grades and quality issues • Product grades including specifications • Processing options describing technical alternatives and their evaluation providing a rationale for process selection
3-Proposed technology	• Process description in detail • Reactor selection (type and rationale for the selection and design characteristics) • Catalyst selection recommendation (type and rationale) if applicable • Key equipment recommendations (description of critical unit operations and equipment selection and design characteristics and key specifications) • Pilot plant and commercial experience (rationale for the proposed design to work as described)
4-Technical and Economic Assessment	• Product applications (major end use markets and competing products) • Competitor assessments by region • Existing capacity (how much and where) • Market forecast (estimate growth rate, future price trends and regional variations in markets) • Project location criteria • Estimated raw materials consumption (as a table) • Estimated utility requirements (type and consumption) • Estimated manpower required (operators per shift) • Estimated installed capital cost based on plant capacity
5-Process Block Diagram	• Design Base case including key conditions • Indicating total production and raw materials consumption
6- Risk analysis	• Process Hazard analysis summary • Environmental impact assessment summary • Commercial risks assessment summary

memo

Table 2. Basic Engineering reporting requirements for Nitric Acid Production Plant – Project CD-05486007-2018. Items to include in BED Report.

Item/Section	Content
Executive Summary	Overall findings and recommendations
Process description and basis	• Project definition: customer, location, key feeds and products specifications, capacity. • Brief description of the process flowsheet including block flow diagram
Process Flow diagrams	• Latest first followed by previous revisions
Mass and energy balances	• Base case (100% capacity, Normal operation) stream data tables: ○ Included in the PFD –stream temperature, pressure, stream total mass flow and molar flow, stream molar composition ○ stream temperature, pressure, mass and molar flow for each component in all streams, stream mass and molar composition and total stream and mass and molar flow. • Base case (100% capacity, Normal operation) physical property data: physical properties required by detailed design teams such as stream density, viscosity, thermal conductivity, etc.
Process simulation and calculations	• Description of how the process was simulated and any differences between the simulation models and the process flow diagram. Any initial estimations or calculations done by hand using perhaps different models to those in the standard Process simulation package should also be described.
Equipment list	• Including nomenclature/legend
Equipment specifications	• Pressure vessels (only separators) • Heat Exchanging equipment • Fluid handling equipment: pumps and compressors Equipment specification should include the essential information and also size of main nozzles (inlets and outlets) and material of construction.
Preliminary hazards analysis and environmental impact	• Description of major process hazards and material hazards of the design • Description of the major sources of environmental impact in the design including outcomes of the Life Cycle Assessment (LCA).
Capital cost estimations	• For each major piece of equipment presented as a table with the total cost
Heat integration and utilities estimates	• Description of how the Heat integration was carried out and relevant results • Breakdown of utility consumption • Changes to the process flowsheet derived from the analysis of heat integration and energy efficiencies (if applicable comparison with other values reported in literature for a similar process).
Design decisions and assumptions	• Description of the most significant assumptions and selection decisions including reference to calculation sheets.
Appendices	• Calculation sheets to support equipment sizing and selection for each equipment item included in the Equipment Specification Sheets and cross-referenced to correct equipment number.

memo

For the purposes of the BED report submission please group items as follows;

Part 1-
Items: Executive summary, Process description and basis, Process simulation and calculations, Preliminary hazards analysis and environmental impact, Capital costing and Heat integration and Decision and assumptions. This part should be no longer than 15 pages in total.

Part 2-
Items: PFDs, Material and energy balances, Equipment list
All drawings (PFDs) should be done according to industry standards and paper size A3.

Part 3-
Items: Equipment Specification sheets, Appendices
Equipment specifications should have at least the number of specification sheets equating to team members (e.g. 6 member teams should have at least 6 Equipment specification sheets). This section should also include at least three types of equipment: pump/compressors, heat exchangers and separators.

Calculation sheets (Appendices) should include the calculations associated to all pieces of equipment reported in the Equipment specification. Calculation sheets should have a clear and logical structure and include in each case the name and signature of who performed and checked the calculations.

Each part should be submitted separately.

Appendix 2 – Consent form

Consent Form for CP-306 Process Design and Advanced IT class audio- and video-recording

Name of department: Chemical and Process Engineering
Title of the study: Conceptualization of a shared-regulated model in engineering collaborative learning environments

Please tick appropriately for each item Yes or No on the right hand-side column.		Yes	No
1	I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.	☐	☐
2	I understand that my participation is voluntary and that I am free to withdraw from the project at any time up until the return of the video equipment, without having to give a reason and without any consequences.	☐	☐
3	I understand that any information recorded in the investigation will remain confidential and no written information that identifies me will be made publicly available, though I understand that it is not possible to anonymise any audio or visual details on the video and that myself and the other group members may be recognised visually or orally.	☐	☐
4	I consent to being a participant in the project.	☐	☐
5	I consent to being video recorded as part of the project.	☐	☐
6	I consent to having my raw data stored in the university servers and other data storage facilities.	☐	☐
7	I consent to having my processed data (pseudo-anonymized) to be stored in the university servers and other data storage facilities.		
8	I consent to video images or audio/video extracts being used in presentations or published material and for the purposes of teaching and/or research (e.g., academic presentations or published reports).	☐	☐
9	I consent to the recordings with my data being kept during and for up to 5 years after (October 2026) the end of the study (October 2021).	☐	☐

(PRINT NAME)	
Signature of Participant:	Date:

Appendix 3 – Participant Information Sheet

Participant Information Sheet for CP-306 Process Design and Advanced IT class audio- and video-recording

Name of department: Chemical and Process Engineering
Title of the study: Conceptualization of a shared-regulated model in engineering collaborative learning environments

The following information will appear in Myplace before the submission link for the assessment is available.

Introduction
My name is Diogenes Reyes-Viviescas and I am a PhD student in the Chemical and Process Engineering Department at the University of Strathclyde. I am conducting this research project, under the supervision of Dr Esther Ventura-Medina and Dr Tony Anderson in collaboration with Dr Cristina Mio, to investigate the processes of student learning within groups.

What is the purpose of this investigation?
The purpose of this investigation is to explore behavioural and performance characteristics of students when working in Problem-Based and Project-Based Learning (PBL and PjBL) activities to better explain the direct link between the use of these approaches and the development of the ability to take charge of one's own learning (learner autonomy).

What will you do in the project?
You will be asked to video-record your group meetings for the CP306 class (every week, two hours per meeting). You should act as you normally would while in the group as the aim is to understand what normally happens in student group work. Each of these recorded sessions will take place in university buildings (room tbc).

Do you have to take part?
No, you do not have to take part. It is entirely your decision to take part in the investigation and your participation is voluntary. If, whilst participating in the recorded group sessions, you decide you want to withdraw from the study, you will be given the option to move to another (unrecorded) group, and recordings from the group you leave, which you appeared in, will be destroyed. Regardless of whether you take part in the study or not, your education will not be affected in any way.

Why have you been invited to take part?
You have been invited to take part as you are a student in CP306 *Process Design and Advanced IT*. Not all students need to take part: only few groups of students will be recorded for this project.

What are the potential risks to you in taking part?
There are no potential risks to you in taking part in the project.

What happens to the information in the project?
The information gathered via video recordings from you, your group and other participants will contribute to my PhD project, which is focused on understanding how students work in student groups and how learning takes place across the semesters. The data from the project will also be used for subsequent related projects by Drs Anderson, Ventura-Medina and Mio, but confidentiality will be maintained at all times. Pseudo-anonymity (where names are changed in order to make participants unidentifiable in transcripts) is assured to all participants in video transcripts. However, stills from video footage may be used in academic presentations or publications, and therefore your visual appearance will be visible in such pictures. Short video clips may also be used for academic presentations, where it is important to understand the visual and verbal aspects of social interaction in group work. All recorded data will be

securely stored on the university password-protected and encrypted university data storage facility (I:\ drive), and any hard copies of data (e.g., video recordings) will be kept in a password-protected and encrypted data storage kept in a locked drawer in a locked office. The data will be kept for up to 5 years following the Good Practice Guidelines for the conduct of psychological research. Only the investigators involved in the project (myself, Dr Anderson, Dr Ventura-Medina and Dr Mio) will have access to the raw data.

The University of Strathclyde is committed to transparency and to complying with its responsibilities under data protection legislation. The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 2018. This consent form (privacy notice) has set out important information regarding how we will use you information and rights under the legislation. It is important that you read this notice prior to providing your information. The University of Strathclyde is a data controller under protection legislation.

Any enquiries regarding data protection should be made to the University's Data Protection Officer at dataprotection@strath.ac.uk

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

What happens next?
If you are happy to be involved in the project, please complete the consent form to confirm this.

If you no longer wish to be involved with the project, thank you for your attention thus far.

Once the project is completed, if you are interested, we will be happy to inform you of the findings by way of posting or emailing you my report.

Researcher Contact Details:
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This investigation was granted ethical approval by the Departmental Ethics Committee (DEC).
If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Convenor of the Ethics Committee
Department of Chemical and Process Engineering
University of Strathclyde
75 Montrose Street
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Appendix 4 – Data management plan

Development of learner autonomy in student-centred learning environments in engineering

Administrative Data

Creator

Diogenes Reyes-Viviescas

Creator Department

Chemical and Process Engineering Department

ID

xsb16198

Co-investigator(s)

Dr Esther Ventura-Medina, Anthony Anderson, and Cristina Mio

Co-investigator(s) contact details

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Project title

Development of learner autonomy in student-centred learning environments in engineering

Project Description

This project investigates the behavioural and performance characteristics of students when working in Project-Based Learning (PjBL) activities to elucidate the link between the use of these approaches and the development of learner's autonomy. It explores the role of 'reflection' and 'self-regulation' in the progressive development of intellectual skills and

metacognition that can lead to autonomous learning. The proposed project build on existing and recently collected research data within the SkIL group, and uses qualitative methods to examine the behaviour of learners in actual teaching settings.

Funder

University of Strathclyde (Partial Scholarship)/Diogenes Reyes-Viviescas

Grant reference number

N/A

Project start date

01/10/2018

Project end date

01/10/2021

Date of first version

05/02/2019

Date of last revision

01/06/2021

Related policies

- University of Strathclyde Research Data Policy
- University of Strathclyde Research Data Deposit Policy
- University of Strathclyde Information Governance and Compliance
- University of Strathclyde Research Code of Practice
- University of Strathclyde Policy and Code of Practice for Post Graduate Research Programmes
- University of Strathclyde Information Security Policy
- RCUK Common Principles on Data Policy
- Good Practice Guidelines for the conduct of psychological research
- General Data Protection Regulation

Existing data

A set of audio and video files collected in the 2017-2018 Cohort

Data Collection

What data will be collected or created?

For the development of the project, student groups will be recorded so video footage and audio files are going to be generated.

How will the data be collected or created?

Data generated will be created using:

- Two video cameras are set up opposite sides and an audio recorder over the table in a room where students' meetings will take place; once the sessions finish, files are copied in a drive and then, transferred to an already assigned storage space (I:\Engineering\ChemEng\SkILResearchGroup).
- Forms (feedback) will be filled out by students when required, then scanned and stored in a safe place so researchers can access them for their analysis.

Documentation and Metadata

What documentation or metadata will accompany the data?

Each dataset will be accompanied by the appropriate metadata which will state what the data are, when they were collected, and what file type and file size. The documentation will further this by noting not only the objective aspects of the data but for it to be easily understandable by other researchers. This includes the naming conventions as well as how data were grouped and organised should this be forgotten or need to be passed on to new researchers.
There are different ways to provide metadata and documentation but for this project, it will be completed for a collection level so it is provided for a collection of data rather than for each item separately.

Ethics and Legal Compliance

How will ethical issues relating to data be managed?

The main ethical issue for this project is that the data collected can be seen as sensitive. It requires consent from participants for data collection, storage and sharing. This required an Ethics application form to be completed and amended according to the Department Committee requirements. Once this had been accepted, recruitment began and then consent forms were signed. Other ethical issues related to the storage and security of the data, these are further discussed in the following section of this data management plan.

How will copyright and Intellectual property (IPR) issues be managed?

There are no copyright and Intellectual property issues. Regarding the data access, once the project is completed; according to the Good Practice Guidelines for the conduct of psychological research, the raw data will be kept for 5 years, this is explained to the participants.
Before this though, there will be a comprehensive selection of data to decide what should be kept and what can be disposed of.

Storage and Backup

How will data be stored, backed up and shared during the research project?

All the data that are downloaded will be stored and saved on an encrypted university secure-cloud sharing service (I-Drive). A back-up copy will be created and saved to an encrypted-external hard drive that is kept in a locked drawer in a locked office at the University.

How will access and security to data be managed during the research project?

The only people that have access to these data are the investigators in this project. The data, as explained above, will be stored securely using encryption to prevent any persons without permission to gain access. Every copy of data has at least two levels of protection.

Selection and Preservation

Which data should be retained, shared, preserved and destroyed

Then will be an extensive process at the end of the project to establish the important data to be preserved and that to be destroyed. However, while the project is active all raw data files will be kept and will be kept for 5 years after it is last accessed following the Good Practice Guidelines for the conduct of psychological and educational research.

What is the long-term preservation plan for data?

The preservation plan for the data is to keep them stored on an encrypted university secure-cloud sharing facility, where it can only be accessed by researchers involved in this project or following projects led by other PhD students using the data. It will be kept for 5 years after the last time it was accessed.

Data Sharing

How will the data be shared?

Due to the personal nature of these data, and according to the ethical requirements of the project, the data will only be shared with the researchers involved in the project. Only they will have access to the raw data.

Are any restrictions on data sharing required?

The data will be anonymised before being published or used for dissemination, the students will be given pseudonyms. The raw data will not be shared with any academics other than the researchers involved in the project.

Responsibilities and Resources

Who will be responsible for data management?

The Principal Investigator: Diogenes Reyes-Viviescas will be responsible for data management.

What resources will you require to deliver your plan?

It is necessary to create a secure encrypted folder (I-Drive) that can only be accessed by those involved in the project and using the data for research purposes. Due to the nature

of the data, video recordings, they are often very large files so this folder must have the appropriate level of storage for all of the files. If this does not happen, all files will need to be stored on encrypted hard drives which are not a reliable storage method because they can be vulnerable to damage or breakages.