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**Self and social regulation of learning during scientific inquiry activities
A naturalistic study with Turkish upper primary school students**

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**Self and social regulation of learning during
scientific inquiry activities: A naturalistic study
with Turkish upper primary school students**

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**A thesis submitted in partial fulfilment of the requirements for a PhD
degree at King's College London**

**School of Social Science and Public Policy
Department of Education and Professional Studies**

King's College London

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Abstract

Scientific inquiry learning has received considerable attention in many science curriculums around the world. It is viewed as an effective instructional approach in which students actively and collaboratively learn about the nature of science and the science content by engaging in various inquiry processes. In order to benefit from the learning opportunities presented by this approach, it is considered crucial for students to engage in self and social regulation of learning processes. While recently a number of studies have been conducted to examine students' self-regulation of learning processes, the empirical research on social aspects of regulation of learning during scientific inquiry learning is still scarce and insufficient. This qualitative study explores if and how Turkish upper primary school students (aged 12, grade 7) self and socially regulate their learning in the context of classroom-based scientific inquiry learning activities. Two groups of three students and their science teacher were studied from a private primary school in Turkey. Participants were observed and videotaped during scientific inquiry activities in a naturalistic classroom setting over a seven-week period. Their verbal and non-verbal interactions within the video data were analysed in order to identify self and social regulation of their learning processes. Moreover, this was combined with the analyses of stimulated-recall and semi-structured interviews with the student groups, and the field notes as well as relevant documents collected during classroom observations.

The results of this study show that students engaged in self-, co-, and shared regulation of metacognitive, motivational and emotional processes, and these regulation processes were crucial for their successful engagement in the scientific inquiry activities. Co-regulation and shared regulation of metacognitive processes commonly emerged when the students expressed a misconception or uncertainty or a lack of understanding about a scientific idea through a variety of questions and statements, and this commonly had the function of facilitating the construction of a new scientific understanding. Further, the results of this research revealed that the student groups used increasingly more shared metacognitive regulation processes over time across the sequence of small group inquiry activities. It also emerged that the positive quality of interpersonal interactions amongst the participants was observed to create a favourable social climate, which facilitated the occurrence of co-regulation and shared regulation of metacognitive processes. Moreover, the use of co-regulation and shared regulation of motivational and emotional processes was identified as important in terms of helping the students maintain successful engagement with the task as well as creating and sustaining a positive socioemotional climate during the scientific inquiry activities. Furthermore, the results of this thesis show evidence of interplay between the different types of regulation processes. This thesis concludes with implications for practice and recommendations for future research.

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Chapter 1 – Introduction

1.1 Background

In recent years, the need to create a society of scientifically literate citizens has been seen as vital in many countries and is increasingly accepted as the primary goal of school science education around the world (Deng, 2010; Martins, 2010; McGregor & Kearton, 2010; Roberts, 2007; Schwartz *et al.* 2004). That is, achieving scientific literacy among citizens is seen as critically important for promoting collective economic well-being, societal coherence and democracy in the increasingly scientific and technological societies of the new century (Dillon, 2009; McEneaney, 2003). Scientifically literate individuals are thought to benefit from increased economic prosperity and job opportunities, wiser decision-making processes about socioscientific issues, and increased interest and confidence in science and technology (Dillon, 2009; High Level Group on Science Education, 2007; Norris & Philips, 2003).

In order to attain the goal of scientific literacy, it is commonly acknowledged that individuals must be provided with an understanding of science that enables them to engage actively in critical dialogues concerning science and technology related issues, understand scientific claims, and make thoughtful decisions on personal and societal levels (Abd-El-Khalick *et al.*, 2004; Irez 2006; Ryder, 2001). Thus, achieving scientific literacy entails students not only acquiring knowledge of science concepts and theories, but also developing understanding of the nature of science and scientific inquiry (Flick & Lederman, 2006; Lederman & Lederman, 2010; Pollen, 2009a; Schwartz *et al.* 2004). In this respect, scientific inquiry learning and teaching has received considerable attention in many science curriculums as one of the important elements of scientific literacy (Bell *et al.*, 2009; Lederman & Lederman, 2010; Schwartz *et al.* 2004).

Turkey has been one of the countries that has recently redesigned its science curriculum around inquiry learning principles. In 2005, the Turkish Ministry of Education and Board of Education introduced the new science and technology curriculum for primary education grades 4 to 8 (9–13 years) (Ministry of National

Education [MoNE], 2006). The stated vision of the new science and technology curriculum is to raise scientifically and technologically literate students regardless of their individual differences in order to prepare them for the challenges of 21st century (MoNE, 2006). In the new curriculum, in order to attain scientific literacy, all students are expected to develop scientific inquiry, critical and creative thinking, problem solving and decision making skills, become lifelong learners, and acquire necessary attitudes, values, understanding and knowledge to maintain a sense of curiosity concerning science, the environment and the world (*ibid*). According to the curriculum standards, scientifically literate individuals are characterised as more effective in accessing and using scientific knowledge, solving problems and taking into account the possible risks, benefits and available options when making decisions about the issues related to science and technology (MoNE, 2008). They are also expected to understand the relationship between science, technology, society and the environment; realise social, economic and ethical values about science and technology; be aware of the personal health and environmental problems; and use scientific knowledge, understanding and skills in their professional life to improve their economic efficiency (MoNE, 2006).

Like its counterparts in many other countries, the scientific inquiry approach in Turkey is valued and seen as being vital in achieving the overall objective of the new science and technology curriculum, which is the promotion of scientific literacy among all students. In the new curriculum, scientific inquiry is perceived as both a content goal and a pedagogical approach, similar to the conceptualisations suggested in the current literature (see Bybee, 2006, 2011; Flick & Lederman, 2006; Lederman & Lederman, 2010; van Joolingen & Zacharia, 2009). As a content goal, the new curriculum emphasises students developing the abilities of making scientific inquiry and having an understanding of what it entails. For instance, it is suggested that students should:

- acquire and use science processes skills with the purpose of learning and understanding the ways and methods of scientific inquiry,
- have the ability to inquire, examine, make a connection between their everyday lives and science topics,

- utilise scientific inquiry methods to solve the problems faced in every aspect of life and look at the world from the perspective of a scientist (MoNE, 2006, p.64).

Being based on a constructivist approach, the new curriculum also views scientific inquiry as a pedagogical approach that engages students in learning about scientific concepts and the nature of science. Consequently, teachers are expected to create a suitable and supportive environment for students' active learning through inquiry, discovery and collaboration (MoNE 2006). For example, it is stated that in order to promote scientific literacy, a variety of student-centred activities should be utilised by teachers that:

- provide students with opportunities to learn and discover scientific concepts through inquiry, experiments and collaboration,
- encourage students to use inquiry methods to seek answers to scientific questions while interacting with the world around them (*ibid*, p.15-17).

In the new curriculum, the 5E instructional model is used in order to structure the learning activities around the principles of an inquiry learning approach (MoNE, 2008). This model includes engagement, exploration, explanation, elaboration and evaluation phases, which are assumed to engage students actively and collaboratively in scientific inquiry processes and help them construct new scientific understanding over time. Moreover, during these phases, students are expected to engage in both collaborative small group and whole class activities. More specifically, while engaging in small group work, they are expected to:

- ask inquiry questions, propose predictions and hypotheses about a scientific concept or phenomenon,
- design and carry out investigations,
- explore the inquiry questions by collecting and analysing various sources of information and evidence,
- share and discuss each other's explanations and viewpoints,
- critically listen to and probe each other's ideas,
- create new scientific explanations and understanding (*ibid*, p.9-8).

In whole class activities, it is expected that students should communicate and negotiate their individual and shared ideas with the class, extend their understanding of the science concepts, and ask further inquiry questions for future investigations (*ibid*).

Similar to the new science and technology curriculum, much of the current literature also views scientific inquiry learning as an effective instructional approach in which students actively and collaboratively learn science through engaging in various inquiry processes, such as formulating questions and hypotheses, planning and carrying out experiments, collecting and analysing data, constructing explanations, drawing conclusions and communicating new scientific ideas to a wider audience (Harris & Rooks, 2010; Lee *et al.*, 2010; Pollen, 2009b; Quintana *et al.*, 2005). That is, this way of learning is assumed to promote students' motivational engagement and interest in science (Collins, 1997; Minstrell, 2000; Singer *et al.*, 2006) as well as enhancing their scientific literacy and understanding of the nature of science (Bell *et al.*, 2009; Lederman & Lederman, 2010; Schwartz *et al.*, 2004). It is contended by a number of scholars that students who engage in scientific inquiry learning are more likely to achieve a better conceptual understanding (e.g., White & Frederiksen, 1998; Williams & Lin, 2002).

With the scientific inquiry approach, effective collaboration and social interactions are also seen as important in the generation of new scientific knowledge and understanding. To this end, it is often proposed that when engaging in scientific inquiry activities, students should be provided with opportunities to make explicit their questions, ideas and explanations so that they can share as well as critique and debate in a collaborative way (Bell *et al.*, 2009; Lee *et al.*, 2010; Urhahne *et al.*, 2010). Engaging in collaborative discourse is believed by many educational researchers to support students' learning through helping them clarify and justify their thinking, build on and refine one another's ideas by comparing different perspectives, and jointly co-construct scientific knowledge and understanding (Bell *et al.*, 2009; Cavagnetto *et al.*, 2010; Osborne, 2010). Overall, scientific inquiry learning is almost invariably assumed to result in deeper and more meaningful learning, because the students are involved in the processes of science in an active,

collaborative and authentic manner (Lee *et al.*, 2010; Kim *et al.*, 2007; Manlove *et al.*, 2006).

Nevertheless, despite the promises of scientific inquiry learning, it is also commonly acknowledged that scientific inquiry learning is often challenging for students of all ages, as it includes open-ended, ill-structured learning tasks, and entails taking on more responsibility for learning, effective collaboration with peers as well as increased intellectual effort (Blumenfeld *et al.* 2006; Harris & Rooks 2010; Järvelä *et al.*, 2008a; Manlove *et al.*, 2007). In support of this perspective, a number of previous studies indicate that most students have problems with many aspects of scientific inquiry learning. For example, the reviews by de Jong (2006a & b) and Wu and Hsieh (2006) show that students often have difficulty in formulating testable hypotheses, designing conclusive experiments, interpreting data, constructing and justifying scientific explanations, and differentiating explanatory claims with evidence.

Furthermore, due to its collaborative nature, scientific inquiry learning presents other challenges. Regarding this, prior studies reveal that students do not always readily engage in the productive interactions necessary for effective collaboration, such as developing a shared goal for a joint activity, negotiating multiple perspectives, co-constructing shared knowledge or sharing and maintaining a joint focus of attention (Barron, 2003; Dillenbourg *et al.*, 2009; Clark *et al.*, 2007; Slob *et al.*, 2010). Students may also experience a variety of emotional and motivational challenges while collaborating with each other. As the review by Järvelä *et al.* (2010) shows, these challenges can negatively influence a group's collaborative interactions and motivational engagement, and can arise for a variety of reasons, such as differences in students' personal goals, priorities and expectations, conflicts generated by the group's interpersonal dynamics or collaborative processes, such as experiencing low level of commitment and attention, lack of common ground in a shared activity or having multiple, conflicting perspectives.

Given the complex nature of scientific inquiry learning, in order to benefit from the learning opportunities presented by this approach, it is considered critical for students to engage in metacognitive, motivational and emotional regulation processes both socially and individually. For example, it is widely accepted by many

researchers that it is necessary for them to utilise metacognitive regulation processes, such as setting learning goals, creating plans for the inquiry task, selecting and applying the most appropriate strategies, monitoring emerging understanding of the content, and evaluating the learning process (de Jong & van Joolingen, 1998; Graesser *et al.*, 2007; Hogan, 1999; Manlove *et al.*, 2006; White *et al.*, 2009; Winters & Azevedo, 2005). Moreover, in order to maintain successful motivated engagement and effective interactions, it is seen as essential for students to regulate their emotional and motivational processes in order to overcome challenging situations, which may emerge during scientific inquiry activities (Järvenoja & Järvelä, 2009; Wolters, 2003).

In recent years, a number of research studies have been conducted to examine how students regulate their learning processes and how students' regulation of learning could be supported during scientific inquiry learning activities (Davis & Linn, 2000; Graesser *et al.*, 2007; Manlove *et al.*, 2007, 2009; White *et al.*, 2009; Wiley *et al.*, 2009). This line of research has mostly focused on cognitive and metacognitive processes from an individualistic perspective, while mostly neglecting the emotional, motivational and social aspects of regulation of learning. Also, the majority of these studies have been conducted within experimental settings, rather than analysing students' regulation of their learning processes while occurring within naturalistic contexts (Manlove *et al.*, 2007; Raes *et al.*, 2011; Winters & Azevedo, 2005). Moreover, most of these studies have been carried out in Western countries, while there has been no regulation of learning research undertaken in relation to scientific inquiry learning in Turkey.

In contrast to the individualistic perspective of earlier studies, most recent research suggests that in social learning situations students can engage in both self and social forms of regulation processes (Hadwin *et al.*, 2010; Iiskala *et al.*, 2011; Järvenoja & Järvelä, 2009; Volet *et al.*, 2009a). It has been contended that in addition to self-regulating their cognitive, motivational and emotional processes, they can also engage in co-regulation of learning, in which one student(s) temporarily supports another's regulation, or shared regulation of learning, whereby multiple individuals regulate their collective activity in order to achieve a shared goal. Consequently, it is becoming increasingly acknowledged that in order to understand better individual

and group engagement in social learning situations, it is essential to focus on both self and social aspects of regulation processes (Hadwin & Järvelä, 2011; Iiskala *et al.*, 2011; Volet *et al.*, 2009a).

In the current literature, the empirical research on social regulation processes is still scarce and insufficient, as the majority of previous work has focused on students' self-regulation of learning from an individualistic perspective. In particular, little is known about how students engage in self and social forms of regulation processes and what roles these regulatory processes may play during their engagement with scientific inquiry activities, especially in the context of the new science and technology curriculum in Turkey.

1.2 An overview of this thesis

Taking into consideration the issues covered in the previous section, this thesis aims to explore, in-depth, if and how Turkish upper primary school students self and socially regulate the metacognitive, emotional and motivational aspects of their learning as they engage in small group and whole class scientific inquiry activities.

In order to do so, a qualitative, naturalistic case study approach was adopted and was conducted with two groups of three students (aged 12, grade 7) and their science teacher from a private primary school in Turkey. Data, including video recordings of the students and teacher engaging in small group and whole class scientific inquiry activities, field notes, interviews, documents, were collected during the progress of undertaking the first unit of the new science and technology curriculum.

This thesis aims to generate in-depth, contextual understanding of how Turkish upper primary school students engage in self and social regulation of learning processes during small group and whole class scientific inquiry activities. That is, by placing an emphasis on students' regulation of learning I seek to develop a detailed understanding of the role of self and social regulation processes in scientific inquiry learning settings. The methodological design utilised in this study is put forward so as to provide other researchers with a template regarding how to proceed with examining self and social regulation of learning in similar settings. It is also hoped that the findings of this thesis may ultimately contribute to improving scientific

inquiry practices through providing insight into how and why students actively self and socially regulate the metacognitive, emotional and motivational aspects of their learning process.

This thesis comprises seven chapters, starting with this introductory chapter, which presents a brief background to this study and an overview of the thesis. Chapter 2 contains a literature review on the current conceptualisations and research on self and social regulation of learning. Existing empirical research on the regulation of learning in scientific inquiry learning is also reviewed in this chapter. After highlighting the fact that there is a lack of empirical research examining social aspects of regulation of learning in scientific inquiry learning settings, three research questions are proposed in order to guide this current research. Finally, the last section discusses the methodological issues concerning the study of the regulation of learning.

In Chapter 3, the methodological approach that informs this thesis is explained and justified. With respect to this, the chapter starts with an explanation of the qualitative approach and epistemological assumptions guiding the research. After justifying the adoption of a case study as the method of investigation for this study, the details of the research design and data collection procedure are provided. Subsequently, the data analysis process is explained and this followed by consideration of the trustworthiness of this research as well as the ethical issues regarding the research.

Chapters 4 to 6 present the findings of this thesis. Chapter 4 describes the evidence regarding the types of metacognitive and motivational and emotional regulation processes used by the upper primary students during the scientific inquiry learning activities. Moreover, an analysis of the relationship between the different types of self and social regulation of learning processes is presented in this chapter.

Chapter 5 extends the analysis of students' regulation of learning processes presented in Chapter 4 by exploring the changes in their use of these regulation processes over time across the sequence of scientific inquiry activities. Furthermore, this chapter examines the intergroup and within-group differences in student's use of metacognitive, motivational and emotional regulation processes over time by taking into account the profiles of each student group.

Chapter 6 addresses the findings in relation to the emergence and functions of social forms of metacognitive regulation processes during scientific inquiry activities. Analysis of the relationship between the quality of interpersonal interactions and social forms of metacognitive regulation processes is also included in this chapter.

Finally, Chapter 7 presents a discussion of the key findings of this study in relation to the previous review of the literature in Chapter 2. It specifically outlines the contributions of this research to understanding students' self and social regulation of learning in scientific inquiry learning. This chapter also discusses the methodological contributions and limitations of this study. Lastly, the implications of the findings of this research for practice and future research are explained.

Chapter 2 – Literature Review

2.1 Introduction

In order to understand students' learning in social learning situations, it is essential to include both self and social regulation of learning processes (Hadwin *et al.*, 2011; Iiskala *et al.*, 2011; Volet *et al.*, 2009a). However, while the current literature involves extensive conceptual and empirical studies on self-regulation of learning (SRL), the empirical research on social regulation of learning is still scarce and insufficient, especially in relation to scientific inquiry learning, and this is non-existent at the primary school level in Turkey. In addressing this research gap, this thesis is aimed at extending SRL (Pintrich, 2004; Zimmerman, 2000) and social regulation of learning literature by presenting a qualitative analysis of Turkish upper primary students' self and social forms of metacognitive, motivational and emotional regulation processes during small group and whole class scientific inquiry activities.

The literature review presented in this chapter highlights the current theoretical and methodological perspectives in the study of self and social regulation of learning as well as discusses the related empirical research on scientific inquiry learning. Following a critical review of SRL theory and research, I will examine current conceptualisations and research on social regulation of learning in detail. Next, the relevant empirical research on scientific inquiry learning will be scrutinised. After providing the research questions of this thesis, finally, I will discuss the methodological issues concerning the study of the regulation of learning processes.

2.2 Self-regulated learning

Emerging mostly from a social cognitive theory, SRL has become a prominent and fruitful research topic in the field of educational psychology in recent years, and is viewed as playing a key role in influencing learning and achievement, both in and beyond the school environment (Boekaerts & Cascallar, 2006; Zimmerman & Schunk, 2011). It commonly refers to an active, constructive process in which students intentionally set learning goals and then attempt to plan, monitor and

regulate their cognitive, behavioural, motivational and emotional processes in the service of those goals in order to achieve optimal learning (Azevedo *et al.*, 2011; Pintrich 2000; Winne & Hadwin, 2008).

The extant literature includes various conceptualisations and models of SRL each of which emphasises different aspects of SRL depending on the theoretical perspective they rely on (Boekaerts & Corno, 2005; Puustinen & Pulkkinen, 2001; Zimmerman, 2012). Nevertheless, in recent years, a consensus has emerged in relation to many aspects of SRL theory (Hadwin *et al.*, 2011; Johnson *et al.* 2011). In order to provide a most recent view of SRL theory, this section focuses on the common assumptions shared by most theoretical models of SRL (please see Appendix A for an overview of three popular SRL models).

Currently, there is a general consensus that self-regulated students are active agents in their learning processes who are metacognitive, motivated for learning, and strategic (Winne & Perry, 2000; Zimmerman, 2008). That is, these types of students utilise metacognition to analyse the demands of particular tasks in relation to personal strengths and weaknesses, and then regulate engagement with tasks so as to optimise learning processes and products (Perry *et al.*, 2010). Moreover, they are highly motivated for learning, as they value personal progress and deep understanding, have high efficacy for learning, show willingness to attempt challenging tasks, and persist when faced with challenges (Winne & Perry, 2000). They are also strategic as they usually choose and apply the most suitable and effective learning strategies which they believe are best suited to the task conditions. There is much empirical evidence showing that students with high use of SRL processes demonstrate higher academic achievement than less self-regulating ones (e.g., Greene & Azevedo, 2007a; Winters *et al.* 2008; Zimmerman & Schunk 2011).

In the current literature, most of theoretical models characterise SRL as involving multiple components and phases (Azevedo & Chauncey Strain, 2011; Boekaerts & Cascallar, 2006; Pintrich, 2000; Winne & Hadwin, 2008; Zimmerman, 2008). In particular, it is assumed that self-regulated students have the potential to engage in continuous and concurrent regulation of metacognitive, behavioural, motivational and emotional processes through following a series of phases (or processes) while performing the learning task.

Across most SRL models, metacognitive (or cognitive) regulation is described as a recursive activity which involves planning, monitoring, control and evaluation of cognitive processes. Regarding the foremost, students usually analyse the learning situation, activate knowledge about the task and context, set learning goals, create plans according to their goals, and decide which learning strategies to utilise (Azevedo, 2007; Järvenoja, 2010; Perry & Winne, 2006; Pintrich, 2004; Zimmerman, 2011). Next, while implementing the plans and strategies, they engage in a monitoring process in which they become aware of and monitor their emerging understanding or progress toward goals or task standards (Pintrich, 2004). Moreover, if necessary, they can engage in a control process in which they make adaptive adjustments in their cognitive processing based on the information created by the ongoing monitoring process (Perry & Winne, 2006; Pintrich, 2004). Further, the evaluation process involves reaction and reflection of students on their content understanding and task performance in relation to the entire task (Manlove *et al.*, 2007; Pintrich, 2004). Regarding the aforementioned behavioural aspect of regulation, the individual students attempt to sustain on-task behaviour through time and effort planning, monitoring of effort, time use and need for help, and control of effort and help-seeking (Pintrich, 2004).

While the models of SRL originally emphasised cognitive and metacognitive processes, in recent years, motivation and emotions have been increasingly considered as aspects of the learning process which students can actively regulate. Currently, in many contemporary models, regulation of motivational and emotional processes is seen as an important facet of SRL (Boekaerts, 2007; Pintrich, 2004; Winne & Hadwin, 2008; Wolters, 2003, 2011; Zimmerman, 2011). Regarding this type of regulation, at the start of a particular task, students generate various motivational beliefs, feelings and emotions based on their previous experience with the learning topic, success with the task, and situational demands (Azevedo, 2007; Pintrich, 2004; Winne & Hadwin, 2008). Subsequently, during their learning, they monitor their own level of motivation or motivational processing, feelings and emotions, and when necessary, apply a variety of strategies to purposefully intervene and control their motivational state or emotional experience in order to sustain their engagement, willingness, and goal-oriented actions (Järvenoja, 2010; Pintrich, 2004;

Wolters, 2003, 2011). Following a particular learning session, they may also have emotional reactions or make motivational attributions which can influence subsequent learning (Pintrich, 2004). Effective use of motivational and emotional regulation processes is considered to have a positive influence on learners' level of motivation, engagement and academic performance (Chauncey & Azevedo, 2010; Järvelä & Järvenoja, 2011; Wolters *et al.*, 2011).

In most of the SRL models, it is commonly suggested that the aforementioned different types of regulation processes can occur at any stage of the learning process as well as co-exist simultaneously (Pintrich, 2004; Wolters *et al.*, 2011; Zimmerman, 2011). Furthermore, all these regulatory components and phases are considered to be interacting with each other and influencing students' engagement and learning process (Boekaerts, 2011; Chauncey & Azevedo, 2010; De Corte *et al.*, 2011; Meyer & Turner, 2006; Pintrich, 2004).

Moreover, students' development of self-regulatory processes is assumed to be associated with changes in the regulatory processes themselves as well as changes in biological and experiential factors which influence these regulatory processes (Demetriou, 2000; Wigfield *et al.*, 2011; Zimmerman & Schunk, 2011). Younger students are considered to have less mental capacity to regulate their learning, so it is suggested that there are biological limits on how much learners can regulate their learning at different ages (Pintrich & Zusho, 2002; Wigfield *et al.*, 2011). Also, students' development of knowledge, strategies, and expertise in different areas, such as their self-efficacy, language skills, cognitive strategy use, and affective reactions, are viewed to play a key role in their development of regulatory processes (Wigfield *et al.*, 2011). In the extant literature, much of the previous research has examined the regulation of learning processes with the samples of high school and university students and it has been often assumed that regulation of learning is a late developing skill, emerging at the age of 8 to 10 years (Veenman *et al.* 2006). Nevertheless, a number of researchers have recently challenged this assumption, arguing that methodological difficulties concerning the measurement of younger students' regulation processes (e.g., over-reliance on young children's limited verbal abilities and limited working memory capabilities) have led their regulatory skills being underestimated (Perry *et al.*, 2010; Whitebread *et al.*, 2010). In recent years, several

studies have been able to provide evidence of regulation processes engaged in by young children (Bryce & Whitebread, 2012; Perry *et al.*, 2010; Larkin, 2009). For instance, in one recent study, Whitebread and Coltman's (2010) analysis of classroom video observational data has suggested that children as young as 3-5 years of age were capable of regulating cognitive, motivational and emotional aspects of their learning in the context of mathematical activities.

Across the models of SRL, the focus is always on an individual as a regulator of his/her cognitive, behavioural, motivational and emotional processes, and the social aspect is seen as context in which the regulation processes take place (Järvenoja, 2010; Pintrich, 2004). In line with the social cognitive perspective¹, the relation between the individual learner's SRL process and the social context is commonly considered as being reciprocal and dynamic (Hadwin *et al.*, 2011; Schunk & Usher, 2011). That is, it is assumed that an individual's SRL process can sometimes lead to changes in the structures and conditions of the learning environment (Pintrich, 2004; Zimmerman, 2000), and vice versa, social and contextual influences are viewed as central in influencing and enhancing an individual student's SRL process. That is, from this perspective, social and self are considered as distinct entities whereby the social defines conditions and standards for tasks that influence an individual student's SRL process (Hadwin & Oshige, 2011; Zimmerman, 2000). Also, it is recognised that the social and cultural context provides opportunities for modelling, social guidance and feedback, which each play an important role in supporting the development of individuals' SRL process (Hadwin *et al.*, 2011; Schunk, 2001; Zimmerman, 2000). In summary, SRL from a social cognitive perspective is always conceptualised as an individual process, developing within the individual, while the social context is viewed as an important factor in influencing and promoting individual students' use and development of SRL processes (Hadwin *et al.*, 2010).

¹ According to social cognitive theory (Bandura, 1986), individual functioning is influenced by the reciprocal interactions between personal, behavioural, and environmental factors. The application of this theoretical perspective to SRL assumes that individual attempts to self-regulate learning are not determined just by personal processes, such as cognitive or affective ones, but also these processes are influenced by behavioural and environmental factors that are assumed to be in a reciprocal interaction with each other (Schunk, 2001; Zimmerman, 2000).

Given the widespread acceptance in recent years of the importance of SRL for successful academic achievement, the existing literature includes a great deal of empirical research on SRL. An overview of this area of research is illustrated in the next section.

2.2.1 Research on self-regulated learning

In line with the assumptions and claims of SRL models, a number of research studies have focused on examining the processes individual students use to regulate various aspects of their learning within a variety of learning situations. Research in this area has focused on a variety of tasks from different domains, as well as different age groups of students, ranging from pre-elementary school to university students. Moreover, several data sources have been utilised, including self-report measures, interviews, computer traces, think-aloud protocols, observations, and performance measures. When scrutinising the existing literature, different lines of research on SRL can be identified, such as including investigations into (a) student characteristics in relation to the use of SRL processes; (b) types of social support for promoting SRL and task engagement; and (c) the features of the social context that facilitate SRL processes.

A number of research studies on the phenomenon have explored how a variety of student characteristics, including achievement level, prior knowledge and self-efficacy, can be influential in individual student use of self-regulation processes. Azevedo and colleagues, in particular, conducted several studies with North American students relevant to this line of inquiry (Azevedo *et al.*, 2004; Greene *et al.*, 2008; Moos & Azevedo, 2008). By using a mixed-methodology approach, they investigated individual students' SRL when learning about complex science topics within a hypermedia learning environment. They utilised think aloud protocol methodology to collect process data about SRL, and assessed learning outcomes by using pre-test and post-test measures. In one particular study, Greene and Azevedo (2007a) investigated how middle and high school students' use of SRL processes during learning with hypermedia were associated with qualitative shifts in their mental models of human circulatory system from pre-test to post-test. Analysis of the data outcomes showed that students who had large qualitative shifts in their conceptual understanding engaged in SRL processes more often than their less

successful peers. More specifically, their findings suggested that utilising certain key SRL processes in relation to monitoring emerging understanding, using effective strategies, and managing aspects of task difficulty and demands were positively associated with the higher qualitative shifts in students' mental model of the circulatory system.

In another study, Moos and Azevedo (2009) investigated the role of prior domain knowledge and self-efficacy² in university students' use of self-regulatory processes and their science learning outcomes. Their results indicated that self-efficacy was positively related to students' use of specific monitoring processes, such as monitoring their understanding, monitoring their environment, and monitoring their progress towards a goal. Also, prior domain knowledge was found to be significantly related to students' use of monitoring processes. It was also elicited that the relationship between self-efficacy and students' science learning gains was largely mediated by the frequency of use of monitoring processes. In both of these studies, the unit of analysis was always individual students, and the social context was not the focus of the data collection and analysis.

The second line of SRL research examines how a variety of social support mechanisms, such as modelling³, scaffolding⁴, and feedback from peers and teachers can influence individual students' SRL process and task engagement (Hadwin *et al.*, 2011). For example, in one study, Manlove *et al.* (2007) investigated the effects of a regulative support tool during scientific inquiry learning, the Process Coordinator (PC), on Dutch secondary school students' (aged 16-18) SRL processes and learning

² According to Bandura (1997), self-efficacy refers to one's self-perception of his/her ability to achieve a goal or an outcome.

³ Modelling is described as a process by which observers pattern their 'thoughts, beliefs ... and behaviours, after those displayed by one or more models' (Schunk, 2003, p.160).

⁴ Scaffolding refers to the process through which a more knowledgeable other (teacher or peer) provides assistance that enables students to succeed in activities which they cannot accomplish successfully on their own, and supports them in developing knowledge and skills necessary for performing future tasks independently (Quintana *et al.*, 2004; Tabak, 2004). The aim of scaffolding self-regulation of learning is to assist students cognitively, metacognitively, and motivationally in their regulation of learning, while also helping them develop necessary competence and mastery- (Meyer & Turner, 2002). Scaffolding assistance given to students is always expected to be gradually withdrawn as a result of their increasing competence (Hadwin *et al.*, 2005).

outcomes. Students worked in pairs on an inquiry task about fluid dynamics within a learning environment that included a physics simulation, a data analysis tool, and a model editor that enabled them to generate testable models. Those under the experimental PC + condition received a full version of the PC, which provided them with scaffolds to plan, monitor, and evaluate their learning processes. On the other hand, control students in the PC– condition received no regulatory support, but were provided with an empty PC that included an electronic facility to set, monitor, and evaluate their own goals. Performance was assessed from the students' final models and lab reports, whilst their use of SRL activities was measured from the logfiles. The measured SRL processes included students' planning (adding and viewing goals), monitoring (note taking and viewing, viewing hints, and help-file usage) and evaluation activities (viewing the report template). The results showed that those under the PC+ condition used their PC more frequently and for a longer time than PC– students. They also engaged in goal viewing and note taking activities more than students in the control group, while the latter used the help-file more often. Furthermore, it was observed that both high and low achieving PC+ students benefited from regulatory support and produced better final models and lab reports than the PC– students. In summary, this study evidenced that external PC+ support enhanced secondary school students learning by providing them with metacognitive support to promote better planning, monitoring, and evaluation of their learning process.

In another study, Azevedo *et al.* (2008) investigated the influence of SRL and externally-facilitated self-regulation of learning (ERL) conditions on students' learning outcomes and self-regulatory processes. In this study, 67 high school students (mean age =15) and 61 middle school students (mean age =12) were assigned to one of two scaffolding conditions to learn about the circulatory system using hypermedia. Under the SRL condition, the students were provided with a general learning goal to direct their learning during the learning session. By contrast, those given the ERL condition received the same learning goal, but they were also able to access to a human tutor who facilitated their self-regulatory processes, such as by prompting them to activate their prior knowledge, monitor their learning progress, and use several effective strategies, including summarising, hypothesising,

and coordinating informational sources. The students' declarative knowledge and mental models of the circulatory system were assessed by using pre-test and post-test measures, and according to the former, they were all characterised as having very little prior knowledge about the circulatory system. For both conditions, each student's self-regulatory behaviour was measured individually by using think aloud protocols. Subsequently, self-regulatory behaviours were analysed for several metacognitive activities (planning, monitoring), cognitive activities (learning strategies), and one motivational component (interest). Analysis of the product and process data showed that there was a statistically significant relationship between the acquisition of mental models of the circulatory system and the conditions. That is, 60% of the ERL students had an intermediate or high level mental model, while only 48% of those under the SRL condition achieved the same level of mental models. Furthermore, in terms of acquisition of declarative knowledge, students having the ERL conditions learned more about the circulatory system than students under the other condition. More importantly, besides gaining better mental models and more declarative knowledge, analysis of the think aloud data showed that the ERL students engaged in more self-regulatory processes, such as activating prior knowledge, monitoring, drawing, hypothesising, and coordinating informational sources, than their counterparts. In both Azevedo *et al.* (2008) and Manlove *et al.*'s (2007) studies, the focus of data collection and analysis was on individuals' regulation processes with scaffolding being studied as an independent variable, and hence the actual interactions between participants were not taken into account in the data collection and analysis.

The third line of SRL research explores the features of the learning context that facilitate students' development and use of SRL processes (e.g., Perry, 1998; Perry *et al.*, 2002; Turner & Patrick, 2004). For example, in a study conducted with second and third grade Canadian students during literacy activities, Perry (1998) investigated the influence of types of tasks, authority structures, and assessment practices on students' SRL processes during writing activities, their perceptions of the available control and support, as well as their beliefs, values and expectations in relation to writing tasks. Based on the observations of reading and writing activities, the author identified two types of classrooms in terms of support for SRL, those with high- and

low-SRL classrooms. In the former, teachers engaged students in complex and open-ended writing tasks, provided them with opportunities to control the level of challenge, offered opportunities for them to engage in self- and peer-assessment, provided them with instrumental support, and utilised nonthreatening and mastery-oriented evaluation practices. In contrast, in low-SRL classrooms they were given simple closed types of tasks with limited choices. Also, the challenges and evaluation were highly controlled by the teacher and were typically the same for all students, emphasising performance and making social comparisons among them. Analysis of the classroom observation and interview data suggested that the students in high-SRL classrooms demonstrated attitudes and actions more associated with SRL than students in low-SRL classrooms. In Perry's study, in contrast to the other studies described in this section, both individual students and social context were the focus of data collection and analysis. However, the focus of the analysis was on examining the different types of social context influencing students' SRL processes, rather than focusing on the interactions between the social context and SRL processes.

In summary, as the studies reviewed in this section show, in SRL research, the data has been gathered and analysed about aspects of SRL processes, such as goal settings, metacognition, motivation, strategy use, and self-evaluation, with the individual as the unit of analysis (Hadwin *et al.*, 2010; Zimmerman, 2008). That is, the social aspects of SRL have been always (a) absent in data collection and analysis, (b) manipulated as an independent variable, or (c) examined separately from individual SRL (Hadwin & Oshige, 2011). Accordingly, although the importance of social context is recognised in most SRL models, the examination of interactions between the individuals' SRL process and social influences has not been a focus of this line of research.

2.3 Social regulation of learning

As explained in the above sections, SRL was originally portrayed and studied as an individual process that is influenced by social aspects. By contrast, most recent research has increasingly considered the regulation of learning as a social process at the interpersonal level (see Hadwin *et al.*, 2010; Iiskala *et al.*, 2004, 2011; Järvelä *et al.*, 2010; Volet *et al.*, 2009a; Whitebread *et al.*, 2007). In this regard, it has been

suggested that in social learning situations, besides self-regulating their own learning, students can also engage in co-regulation of learning, in which one student(s) temporarily supports another's regulation process, or shared regulation of learning, whereby multiple individuals regulate their collective activity in order to achieve a shared goal. The following subsections describe the current conceptualisations and research on co-regulated learning and shared regulation of learning.

2.3.1 Co-regulated learning

Co-regulation of learning is described as the temporary coordination of SRL processes amongst self and other(s) (Hadwin *et al.*, 2011). It consists of emergent interactions which temporarily mediate regulatory processes, and give rise to internalisation of self-regulation processes in the service of learning (*ibid*). That is, it refers to a transitional process in which the learner gradually appropriates SRL skills and processes from a more capable other(s) through social interactions over time (Hadwin *et al.*, 2010; McCaslin & Hickey, 2001; Perry *et al.*, 2010). In contrast to a social cognitive perspective that considers self-regulation as an individual process influenced by the social context, the concept of co-regulation is described as a social process in which a student and other(s) (usually more knowledgeable other, such as a peer or teacher) share in the regulation of a student's learning process (Hadwin & Oshige, 2011).

In classroom learning situations, co-regulation typically involves individuals temporarily guiding, supporting, shaping or influencing one another's regulation of the learning process via momentary, asymmetrical interactions. For example, a teacher or peer(s) can co-regulate the learning process of another student who may need assistance with some aspect of the learning task, or a student can request or prompt a peer(s) or teacher to co-regulate his/her own learning process. In each case, the regulation process is shared between the student and other(s), and is always directed at influencing the student's cognition, behaviour or motivation/emotion in order to support and guide his/her learning process (Hadwin *et al.*, 2011; Iiskala *et al.*, 2004; Whitebread *et al.*, 2009).

For successful co-regulation of learning, it is considered important to create an intersubjective task space in which the student and other(s) share rationales and explanations of plans, goals, and activities in relation to the learning task (Järvelä & Järvenoja, 2011). In line with the scaffolding mechanism, it is also considered essential to withdraw gradually the co-regulatory support given to the student, once he/she begins to assume self-regulatory control of his/her learning process (Hadwin *et al.*, 2010).

Previous research provides empirical evidence in relation to students' engagement in co-regulation of learning processes. For example, in line with a sociocultural perspective⁵ of self-regulation, Hadwin *et al.* (2005) examined the transition of self-regulatory control from teacher to graduate student during naturalistic instructional meetings. In this study, the students met with a teacher regarding their graduate research portfolio task at least three times over one year. Their dialogue during the first and the last meeting was analysed and coded into four categories: (a) teacher direct-regulation (instances when the teacher initiated and performed SRL processes for the student), (b) teacher-indirect regulation (instances when the teacher prompted the student to engage in SRL processes), (c) student-indirect regulation (instances when the student requested assistance or information from the teacher to support his/her SRL processes), and (d) student-direct regulation (instances when the student initiated and engaged in SRL processes independently). Of these, teacher-indirect and student-indirect regulation processes were defined as co-regulation of learning. The analysis of the discourse data indicated a decrease in teacher-directed regulation and an increase in student-directed regulation of learning over time. An increase was also identified in the co-regulation of metacognitive processes. Moreover, the teachers usually initiated co-regulation processes through requesting specific information, restating or paraphrasing the students' ideas or explanations, requesting judgment of learning or performance, providing prompts, and making suggestions. Students mainly co-regulated their learning by requesting information, restatement or explanations, requesting judgment of learning or performance, modelling thinking

⁵ According to a sociocultural perspective (Vygotsky, 1978), children's self-regulation first appears on the social or interpsychological plane through social interactions with a more capable other(s), and it is gradually internalised by the child, ultimately appearing on the individual psychological plane (see Zimmerman, 2001).

and summarising. In summary, these authors' study provided evidence of a shift in self-regulatory control from the teacher to students over an academic year, and highlighted the importance of co-regulation processes and interactions in supporting students' appropriation of SRL processes.

In another study conducted in the US, Winters & Azevedo (2005) investigated how high school biology students regulated their learning and utilised co-regulation processes while learning collaboratively with peers about genetics in inquiry-based science lessons. In this study, 62 students (aged 14 to 16) were paired heterogeneously based on their prior knowledge level. Process data was collected and analysed in the form of student discourses as they collaborated while using GenScope, a computer-based learning environment (CBLE). The shift in students' conceptual understanding was also assessed through using pre-test and post-test measures. The findings of this study provided evidence that the low prior knowledge students had significantly higher learning gains than their high prior knowledge partners. Also, the analysis of the students' verbal interactions indicated that those with low prior domain knowledge regulated their learning mainly by relying on co-regulatory support provided by their partner, whereas those at the other end of the spectrum spent most of the time regulating their own learning and providing co-regulatory support for their peers. Moreover, in instances of co-regulation, it was often observed that students with low prior knowledge sought answers from their partner about the procedural aspects of a task and asked for clarification about any conceptual issues that they did not understand. In summary, the outcomes of this study suggested links between the co-regulation of learning and gains in students' conceptual understanding of scientific concepts.

As can be seen from these example studies, the research about co-regulation of learning always focuses on the interactions or dynamic processes between individuals and others, rather than individual aspects of the regulation process (Hadwin *et al.*, 2011). That is, the main research purpose has been to examine and understand the ways in which social practices interact with and enhance individual engagement and regulation processes (*ibid*).

2.3.2 Shared regulation of learning

Shared regulation of learning refers to the process by which multiple group members regulate their joint activity in order to achieve a shared goal (Hadwin *et al.*, 2010; Järvelä *et al.*, 2008; Morris *et al.*, 2010). It is described as collective regulation in which group members ‘develop shared awareness of goals, progress, and task toward co-constructed regulatory processes, thereby sharing regulation processes together as a collective process’ (Järvelä & Järvenoja, 2011, p.353). From this perspective, the responsibility for regulating the joint activity is equally shared among the group members in the service of a shared outcome (Hadwin *et al.*, 2011).

Shared regulation of learning only occurs in socially shared learning situations, such as collaborative inquiry activities, and requires a high level of mutuality within the group, as it emerges and is expressed when multiple group members equally share and socially co-construct regulatory processes (e.g., planning, monitoring, evaluation and strategy regulation) toward a shared goal (Hadwin *et al.*, 2011; Järvenoja, 2010).

Shared regulation of learning is viewed as critical for successful collaboration. While learning collaboratively, besides co-construction of shared knowledge, it is considered highly important for students to regulate jointly the group’s metacognitive, behavioural, and motivational/emotional processes (Hurme *et al.*, 2009; Iiskala *et al.*, 2011; Järvenoja & Järvelä, 2009; Volet *et al.*, 2009b).

The previous research provides empirical evidence in relation to how students use shared regulation processes within collaborative learning situations. For example, in one of the recent studies, Hurme and her colleagues (2009) examined two triads of pre-service primary teachers’ regulation of their group problem-solving activities in a computer-supported collaborative learning context. They particularly focused on investigating how shared metacognitive processes occurring in group problem-solving was associated with the members’ reported individual feelings of difficulty regarding mathematics tasks. The first part of the data of this study consisted of participants’ messages posted on the discussion forum. Through qualitative content analysis, firstly, the messages were categorised whether the messages were metacognitive, cognitive, or social in nature. Next, the metacognitive regulation messages were assessed to see if they were socially shared or individual. The second

part of data collection pertained to students' retrospectively reported feelings of difficulty regarding the problem-solving activity. After combining these two types of data, the researchers analysed group level processes so as to identify different patterns of group interactions during the joint problem solving sessions. The results of this study showed evidence that if the process of socially shared metacognitive regulation was activated and group members actively took part in this process, then, most individual students were able to eliminate their feelings of difficulty. It was also elicited that intentionality, reciprocity, and engagement of group members in the joint problem solving tasks were essential for the occurrence of shared metacognitive regulation processes.

Also, Iiskala and her colleagues (2011) have examined how episodes of shared metacognitive processes relate to the level of task difficulty and students' metacognitive experiences in the context of mathematical word-problem solving activities. In this study, four dyads of high-achieving students (aged 10) from Finland were video recorded while collaboratively solving mathematical word-problems in the computer game environment, 'Quest of the Silver Owl'. Verbal and nonverbal interactions between the dyads during the joint problem solving process were coded by the researchers. Through this, they identified and analysed episodes of socially shared metacognitive regulation in terms of their focus and function. In addition, individual students' metacognitive experiences were also identified within the video data. The results of this study demonstrated that episodes of shared metacognitive regulation tended to emerge more frequently and for a longer duration when undertaking difficult tasks in comparison with easy or moderately difficult ones, but this frequency falls off for extremely difficult tasks. It also emerged that shared metacognitive processes could both facilitate and inhibit a dyads' problem solving activities. Furthermore, students' metacognitive experiences were found to play a key role in initiating episodes of socially shared metacognition. Overall, Iiskala *et al.*'s (2011) study highlights the importance of studying metacognitive regulation as a socially shared process at the inter-individual level within a collaborative learning situation, and not just as an individual process.

In another recent study conducted in the US, Rogat and Linnenbrink-Garcia (2011) focused on shared regulation processes in small collaborative groups of upper-

elementary students (n=24, aged 10). Through qualitative analysis of videotaped observations of the student groups across a series of three mathematics tasks, the researchers identified cognitive (planning and monitoring) and behavioural sub-processes of socially shared regulated learning and examined the variations in the quality of these regulation processes. Furthermore, they investigated the role of group processes (positive and negative socioemotional interactions as well as collaborative and non-collaborative interactions) in explaining the quality variations between the student groups. Their findings revealed that groups engaged in social regulatory processes of planning, monitoring and behavioural engagement while working collaboratively on mathematics tasks, and the quality variation between the groups was related to the synergy among these regulatory processes. Also, these researchers elicited that positive socioemotional interactions and collaboration within the groups appeared to play an important role in facilitating the groups' engagement in high quality shared regulation processes.

In addition, some of the research studies have focused on shared regulation of motivation and emotions during collaborative learning activities. In particular, Järvelä and colleagues have conducted several studies (Järvelä & Järvenoja, 2011; Järvelä *et al.*, 2008; Järvenoja & Järvelä, 2009). For example, Järvelä and Järvenoja (2011) sought to understand how college students jointly regulated group motivation in collaborative learning when experiencing social challenges. In this study, four groups of first-year graduate students (n=16) carried out three different collaborative learning tasks as a part of an educational psychology course. After each task, they filled out a questionnaire aimed at identifying the types of social challenges they experienced in their groups. In addition, the group activities were video recorded to identify shared regulation strategies that they used when facing challenging situations. Finally, the students participated in group interviews in which they were asked to discuss their positive and negative experiences in their groups. The results revealed that the students encountered a variety of social challenges while working collaboratively, including those relating to personal priorities, teamwork, and collaboration. In addition, analysis of the video data showed that each group activated a variety of shared motivation regulation strategies, such as social reinforcement, task structuring, socially shared goal-oriented talk and efficacy

management, in order to increase or sustain the level of group motivation. Overall, Järvelä and Järvenoja's (2011) study provides evidence that the regulation of motivation can be a socially constructed activity, and is highly crucial in social learning situations, because motivation is constantly shaped and reshaped as the collaborative learning process unfolds.

In another study, Järvenoja and Järvelä (2009) focused on how teacher education students regulate their emotions while learning collaboratively. They specifically investigated what kind of socioemotional challenges students faced during group learning situations, and whether they use self and social forms of regulation processes to control the emotions evoked in these challenging situations. 63 teacher education students took part in this study and worked in groups during three collaborative learning tasks. At the end of each task, they all responded to a task specific questionnaire which consisted of two parts. In the first part, they were asked to indicate the types of social challenges they encountered during their learning. The second part focused on the different forms of regulation processes they used to control their emotions and sustain their motivation. The findings of this study indicated that the students experienced different kinds of socioemotional challenges, and engaged in self-, co-, and shared regulation processes in order to control their emotions during collaborative learning.

Furthermore, in a recent study Whitebread *et al.* (2007, 2009) examined young children's (aged from three to five) self-, co-, and shared regulation of learning during independent and collaborative learning activities in nursery and reception classrooms in the United Kingdom. 32 early-years educators and approximately 1,440 children participated in this study which lasted over two years. During this study, the children engaged in learning activities that were designed to be meaningful for them and facilitate their articulation of their regulation of learning. They were able to play and learn individually and collaboratively, and sometimes with the support of an adult. Data collected in this study consisted of video recordings of the children engaging in the various learning activities. All of these were analysed through using an observational coding scheme, which included three main categories, namely metacognitive knowledge, metacognitive regulation, and emotional and motivational regulation. The results of this study showed evidence

that the young children were able to engage in self-, co-, and shared regulation of learning processes in naturalistic, educational settings. Further, more evidence of metacognitive regulation processes was found during the activities in which the children worked in pairs or small groups than when they were working individually or in groups with adult support. In contrast, they mostly engaged in motivational and emotional regulation processes, such as resisting distraction or persisting on a task, while working individually.

As these example studies show, research about shared regulation of learning focuses on collective processes by studying the interactions of multiple individuals (Hadwin & Oshige, 2011). It emphasises mutual interactions and collaboration as the unit of analysis, rather than individual SRL processes or asymmetrical interactions which can lead to the emergence of co-regulation processes (*ibid*). Underlining this perspective, Hadwin *et al.* (2011) point out that whilst the data can be obtained from individual students or via collaborative interactions, the focus of analysis is always on ‘regulated learning processes and constructs that are shared, common to all members, and co-constructed’ (p.70).

2.3.3 Relationship among self and social forms of regulation processes

As illustrated above, self and social forms of regulation processes offer different perspectives for conceptualising students’ regulation of learning. That is, SRL refers to individual processes in which individuals actively monitor, regulate, and control metacognitive, behavioural, and motivational/emotional aspects of their own learning in order to achieve personal goals. Co-regulated learning concerns individuals temporarily supporting or influencing one another’s regulation of the learning process via brief, asymmetrical interactions. Finally, shared regulation of learning refers to the processes by which multiple individuals collectively share and co-construct regulatory processes towards a shared goal.

In the current literature, it is increasingly acknowledged that these three types of regulation processes can occur simultaneously in socially shared learning situations (Hadwin *et al.*, 2011; Iiskala *et al.*, 2011; Järvenoja & Järvelä, 2009; Volet *et al.*, 2009a). Consequently, it is seen as crucial to consider self-, co-, and shared

regulation of learning together in order to obtain a comprehensive understanding of students' engagement and participation in social learning activities (see Hadwin & Järvelä, 2011; Volet *et al.*, 2009a).

Nevertheless, as mentioned earlier, the empirical research on the social aspects of the regulation of learning is still scarce and insufficient when compared with that about individual SRL. In particular, there is a lack of empirical research examining the occurrence of self-, co-, and shared regulation processes together in social learning situations, with the exception being a few recent studies (Järvelä & Järvenoja, 2009; Whitebread *et al.*, 2007, 2009). Furthermore, the majority of the existing studies focus on metacognitive, motivational and emotional regulation processes in isolation as well as either from an individualistic or social perspective. Hence the interplay and interactions among self and social forms of metacognitive, motivational and emotional processes are mostly unknown (see Azevedo *et al.*, 2011; Butler, 2011; Hadwin *et al.*, 2011; Järvelä & Järvenoja, 2009; Salonen *et al.*, 2005; Volet *et al.*, 2009a).

Also, as the recent review by Hadwin *et al.* (2011) also concurs, apart from a few recent studies (e.g., Järvelä & Järvenoja, 2011; Volet *et al.*, 2009b), there has been a lack of empirical research examining how the use of self and social forms of regulation processes changes or evolves over time and across different types of learning contexts. Moreover, as the recent reviews by Hadwin *et al.* (2011) and Volet *et al.* (2009a) point out, while the previous research mostly provides evidence for social forms of regulation processes, there is still a limited understanding of how co-regulation and shared regulation processes emerge and in which ways they may influence students' learning process.

2.4 Regulation of learning research on scientific inquiry learning

As mentioned in the previous chapter, scientific inquiry learning has received considerable attention in many science curriculums around the world (Duschl & Osborne, 2002; Flick & Lederman, 2006; Lederman & Lederman, 2010; Pollen, 2009a). It is viewed as an effective instructional approach in which students actively and collaboratively learn about the nature of science and the science content through

engaging in inquiry processes, such as formulating questions and hypotheses, planning and carrying out experiments, analysing and interpreting data, constructing explanations, drawing conclusions and communicating new scientific ideas to a wider audience (Harris & Rooks, 2010; Lee *et al.*, 2010; Pollen, 2009b; Quintana *et al.*, 2005). It is now widely acknowledged that students learning through the scientific inquiry approach are more likely to achieve a better conceptual understanding (White & Frederiksen, 1998; Williams & Lin, 2002) and have increased motivation and interest in science (Bell *et al.*, 2009; Minstrell, 2000; Singer *et al.*, 2006). Moreover regarding scientific inquiry learning, effective collaboration and social interactions are also generally viewed as important in the generation of new scientific knowledge and understanding. That is, engaging in collaborative discourse is thought to support students' learning through helping them clarify and justify their thinking, build on and refine one another's ideas by comparing alternative perspectives, and jointly to co-construct scientific knowledge and understanding (Bell *et al.*, 2009; Cavagnetto *et al.*, 2010; Lee *et al.*, 2010; Osborne, 2010; Urhahne *et al.*, 2010).

Nevertheless, scientific inquiry learning can be challenging for students of all ages, since it often includes open-ended or ill-structured learning tasks, and entails taking on more responsibility for learning, effective collaboration with peers and an increased intellectual effort than more conventional forms of learning (Blumenfeld *et al.* 2006; Harris & Rooks 2010; Järvelä *et al.*, 2008a; Manlove *et al.*, 2007). In order to be successful, it is commonly acknowledged that students' regulation of learning is essential during scientific inquiry learning. For example, it is seen as necessary for them to use metacognitive regulation processes, such as creating goals and sub-goals, constructing plans for the inquiry task, selecting and applying the most appropriate strategies, monitoring emerging understanding of the content, and evaluating the learning process (Graesser *et al.*, 2007; Manlove *et al.*, 2006; Schraw *et al.*, 2006; Sinatra & Taasobshirazi, 2011; White *et al.*, 2009; Winters & Azevedo, 2005). Furthermore, in order to sustain successful, motivated engagement and effective interactions while collaborating with each other, it is considered essential for them to regulate motivational and emotional aspects of their learning both socially and/or

individually, when experiencing emotional and motivational challenges (Järvelä & Järvenoja, 2011; Wolters, 2003).

In recent years, a number of research studies have been conducted to examine how students regulate their learning process and how their regulatory processes could be supported in scientific inquiry learning activities. However, this line of research has mostly focused on students' metacognitive regulation processes from an individualistic perspective, while mostly neglecting the emotional, motivational and social aspects of regulation of learning. In one of these recent studies, Manlove and colleagues (2009) examined the differences in regulative tool use by pairs and single students within an online scientific inquiry learning environment. 42 students (aged 16-18) from a high-school in the USA participated in this study and either worked individually (n=18) or in pairs (n=12) on an inquiry task about fluid dynamics over five 50 minute lessons. Those under both conditions used two regulative scaffolds which assisted them with planning, monitoring, and evaluating their inquiry learning process; the Process Coordinator (PC) and a laboratory report template. The learning outcomes were assessed through their final models and laboratory reports, and their use of metacognitive regulatory processes (planning, monitoring and evaluation) was measured through using the logfiles. The results of this study revealed that the pairs achieved significantly higher model quality and laboratory report scores than the individuals. In terms of regulative tool usage, paired and single students used the PC for approximately the same duration of time. However, the single students were observed to use the regulative tool in terms of viewing goal lists, taking notes, self-monitoring more frequently than the paired students.

In another study conducted with eighth grade students (n=246) from a middle school in the USA, Peters (2009) investigated the influence of self-regulatory intervention on students' acquisition of the nature of science and science content knowledge. For this research, they were divided into two groups, implicit and explicit, and participated in four guided inquiry lessons about electricity and magnetism. Those in the implicit group learned about the nature of science implicitly through inquiry science activities. Students in the explicit group were given the same inquiry task as the others, but were also provided with metacognitive prompts that helped them to set goals and self-monitor their learning process throughout the inquiry activity. The

learning outcomes were assessed through pre- and post-tests of the nature of science and science content knowledge. In addition, data for qualitative analysis was collected in the form of teacher memos, student work products, think aloud protocols, and focus group interviews in order to explain the processes the students utilised during the inquiry science activities. The results of this study showed that students in the explicit group increased their nature of science and content knowledge significantly more than the students in the implicit group did. Moreover, the qualitative analysis of the data evidenced that the former were more active in paying attention to detail while performing inquiry tasks, and reported placing a higher value on evidence when making conclusions than the implicit group students. The author concluded that explicit intervention of self-regulation can be an effective way of enhancing the nature of science and science content knowledge in students during inquiry science activities.

In recent research, Raes and colleagues (2011) examined the impact of different modes of metacognitive and strategic scaffolding on students' domain-specific knowledge and their metacognitive awareness during an online collaborative inquiry project. 347 ninth and tenth grade students and a group of 17 science teachers from 10 Flemish secondary schools participated in this study. The students were randomly assigned to three experimental conditions (technology-enhanced scaffolding, teacher-enhanced scaffolding, and both types of scaffolding) and a control condition. Those under each condition engaged in a web-based collaborative inquiry science project which consisted of four activities about global warming and climate change. The influence of scaffolding conditions was measured through a pre- and post-test design. Firstly, the students were asked to complete pre- and post- achievement tests in order to determine the learning effect on their domain-specific knowledge. Secondly, they were asked to fill out a modified version of the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) in order to measure changes in their perception of their metacognitive awareness (knowledge of cognition and regulation of cognition) while performing the inquiry task. The findings of this study showed that those receiving teacher-enhanced scaffolding had significantly higher knowledge performance scores compared to those under the conditions of no teacher-enhanced scaffolding. Moreover, it emerged that technology-enhanced scaffolding was more effective in

enhancing the learners' metacognitive awareness when compared with the other conditions without this type of scaffolding. Based on these findings, Raes *et al.* (2011) proposed that combined scaffolding involving both technology-enhanced and teacher-enhanced scaffolding is necessary for enhancing both students' knowledge acquisition and metacognitive awareness during online collaborative inquiry activities.

Similar to the studies covered above, the regulation of learning research on science education in Turkey has also predominantly focused on students' self-regulatory processes, while there has been an absence of research specifically focusing on scientific inquiry learning at any level. In one of the recent research, for example, Akyol and her colleagues (2010) quantitatively investigated the differences in seventh grade students' cognitive and metacognitive self-regulation strategy use in science learning, and the possible contribution of cognitive and metacognitive strategy use in relation to their science achievement level. They also examined whether there was a relationship between students' background characteristics (e.g., age, gender or prior knowledge) and their strategy use and science achievement level. 1571 students from 15 public primary schools participated in this study and were asked to fill out the Turkish version of the Motivated Strategies for Learning Questionnaire (Pintrich *et al.*, 1991) in order to measure their use of cognitive and metacognitive strategies. In addition, the students' science achievement level was measured through a multiple-choice test developed by the authors through taking into account the previous years' nation-wide examinations and instructional objectives of the national curriculum. According to their statistical analyses, there was a significant difference in the level of students' cognitive (rehearsal strategy, elaboration strategy, organisation strategy and critical thinking strategy) and metacognitive strategy use scores. Metacognitive strategy use was reported to be used at higher levels in comparison with other strategies. Moreover, it was elicited that elaboration, organisation, and metacognitive strategy use were significant predictors of students' science achievement levels. Further, the results showed that prior knowledge and socioeconomic status were significantly related to cognitive and metacognitive strategy use and science achievement.

The extant literature also includes a few research studies looking at social aspects of regulation processes in scientific inquiry learning. For example, as explained in detail in Section 2.3.1, Winters and Azevedo (2005) examined how high school biology students regulated their learning and utilised co-regulation processes while learning collaboratively during inquiry-based science lessons. In this study, in addition to self-regulatory processes, collaborating peers were observed engaging in co-regulation of the learning process, which appeared to promote their conceptual understanding of scientific concepts.

In a recent study, Saab and her colleagues (2011) examined how the support conditions of collaborative inquiry learning can affect the use of task and team (group) regulation processes of student pairs. They also investigated the relationship between task regulation, team regulation and students' learning outcomes. 10th grade students (n=96, aged 15 to 17) from six secondary schools in the Netherlands participated in this study and worked in pairs within a computer supported collaborative inquiry environment, called Collisions, which included a computer simulation of colliding particles. The objective of the scientific inquiry task was to discover the underlying physics rules. Students from the same group worked on two different computers and interacted through online chat tools, and there were three different conditions. In the first condition, the student dyads did not receive any support during the inquiry activity (control condition), whereas the students under the second condition received an instruction on effective communication, the RIDE rules (RIDE condition). The third condition dyads received both the RIDE rules instruction and a Collaborative Hypothesis Tool (CHT), which helped them to formulate hypotheses together (CHT condition). The students' regulative activities were measured through analysing chat logs with a single coding scheme for each condition. Regulation of cognitive activities at the individual level was coded as a task regulation, whereas the coordination of the collaboration among the students at the dyadic level was coded as a team regulation. In addition, learning performance was measured through group assignments. The results of this study showed that the dyads overall engaged in more team regulation than task regulation. Further, it emerged that students under the RIDE condition and the CHT condition regulated their team activities more often compared to students in the control conditions. It was

also elicited that the regulation of team activities was positively linked to the learning outcomes under the CHT condition.

In summary, as these example studies evidence, the previous research has predominantly focused on individual cognitive and metacognitive regulation processes, while paying little attention to the emotional, motivational and social aspects of regulation processes. Also, most of these studies have been conducted within experimental settings, rather than analysing students' regulation of their learning processes in real time within naturalistic contexts, and have often been focused on samples of high-school students in Western settings. As a consequence, similar to the other learning contexts, there is still a lack of empirical research investigating the occurrence of self-, co- and shared regulation of metacognitive, motivational and emotional processes simultaneously during scientific inquiry learning activities, in particular in relation to non-Western contexts, such as Turkey.

2.5 Current study and research questions

As the literature reviewed in this chapter illustrates, there is a consensus among most researchers that regulation of learning is both individual and social in nature (Butler, 2011; Järvelä *et al.*, 2010; Hadwin *et al.*, 2011; Iiskala *et al.*, 2011; Volet *et al.*, 2009a). This review has also revealed that in social learning situations, such as scientific inquiry learning, students can engage in three different forms of regulation process: self-regulation, co-regulation, and shared regulation of learning. In addition, this review has provided evidence that students can regulate various aspects of their learning process, including the metacognitive, motivational and emotional aspects, both socially and individually. Thus, in line with the research analysed here, this chapter points out the importance of having a dynamic, integrative perspective of the regulation of learning, which encompasses various types of self-, co-, and shared regulation processes in order to understand better students' learning.

However, as this review has also shown, there is a lack of empirical research examining self-, co-, and shared regulation of learning processes simultaneously in social learning situations, especially in relation to scientific inquiry learning activities in Turkey. In particular, it is still unclear whether and how self and social forms of

metacognitive, emotional and motivational processes are interrelated with one another. Also, there is a limited understanding of how students' use of self-, co-, and shared regulation of learning processes can change or evolve over time and across different types of learning activities. Furthermore, even less is known about how social forms of regulation process emerge and in which ways they may influence students' individual and joint learning processes. Also, as stated previous sections, much of the research in the extant literature has examined the regulation of learning processes with the samples of high school and university students, and hence there is still a lack of research with younger students, especially during scientific inquiry learning activities at the primary school level.

In order to address the research gaps identified above, the study presented in this thesis investigates Turkish upper primary students' (aged 12, grade 7) self-, co-, and shared regulation of their metacognitive, motivational and emotional processes during their engagement in scientific inquiry activities. The research questions guiding this thesis are as follows:

1. Do students use self-, co-, and shared regulation of metacognitive, motivational and emotional processes during scientific inquiry activities, and if so, what relationship exists between the types of these regulation processes?
2. How does students' use of regulation processes change over time across a sequence of whole class and small group activities?
3. How do social forms of metacognitive regulation processes emerge and function in the context of scientific inquiry activities?

In the next section of this chapter, I will discuss the methodological issues in relation to studying the self and social aspects of the regulation of learning processes.

2.6 Methodological issues in researching regulation of learning

Research on self and social forms of metacognitive, emotional and motivational regulation processes presents a challenge in terms of its design and finding the ways to measure and analyse these processes. This section contains discussion on the

instruments available for measuring students' regulation processes, thereby highlighting some of the methodological issues encountered when carrying out such research.

Researchers in this field have utilised a variety of research procedures and a broad range of measurement instruments depending on the conceptualisation of SRL (Cascallar *et al.*, 2006; Zimmerman, 2008). For instance, those who conceptualise the regulation of learning as an aptitude, 'a relatively enduring attribute of a person that predicts future behaviour', have mostly relied on prospective and retrospective self-report instruments to measure various aspects of students' regulation of their learning processes (Winne & Perry, 2000, p.534). The researchers adopting this approach mostly have utilised questionnaires and structured interviews to measure students' reported use of regulation strategies either before, after, or independent of a particular learning task.

As one of the most commonly used self-report measures, questionnaires usually consist of Likert-styled scales used to measure the frequency of students' reported use of regulation processes (Boekaerts & Corno, 2005; Winne & Perry, 2000). One example of this type of instrument that has been widely used around the world is the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich *et al.*, 1991), which measures motivational beliefs and cognitive and metacognitive strategy use in undergraduate students. Another example is the motivational regulation strategies survey developed by Wolters (1999), which measures the use of motivational regulation strategies in high school students. Self-report questionnaires are viewed as advantageous, since a great deal of data on various aspects of SRL can be collected and analysed from a large number of respondents quickly and efficiently (Winne & Perry, 2000; Wolters *et al.*, 2011).

Concerning interviews, they allow researchers to gather information about SRL through eliciting students' explanations of their beliefs, attitudes, behaviours or experiences (Boekaerts & Corno, 2005; Patrick & Middleton, 2002; Perry *et al.*, 2002; Wolters *et al.*, 2011). Types of interviews used to explore SRL include unstructured, structured and semi-structured forms. In unstructured interviews, students are asked to give their stories and data are usually presented as narratives

(Boekaerts & Corno, 2005). In contrast, structured interviews involve asking participants critical questions that build on one another (*ibid*). Semi-structured interviews enable researchers to select and ask a variety of context-sensitive questions that encourage students to reflect on their thoughts, feelings, and strategy use during a learning task. One well-known example of a semi-structured interview is the Self-Regulated Learning Interview Schedule (SRLIS) (Zimmerman & Martinez-Pons, 1988), which aims to elicit information about various aspects of SRL through having students think about a contextualised, but fictitious learning task.

Self-report measures have been useful in providing valuable information about students' perceptions of how they regulate their learning, as well as quantitatively identifying whether and how various facets of SRL are interrelated and relate to other relevant constructs, such as academic achievement (Perry *et al.*, 2002; Zimmerman, 2008). However, they have been also widely criticised as having limitations when studying the regulation of learning processes, especially with younger children with limited verbal and working memory abilities (Whitebread *et al.*, 2010). Perry and Winne (2006) pointed out two important limitations of the validity of self-report instruments used to measure students' regulation of learning processes: context and calibration. Regarding the former, when a self-report instrument measures the regulation of learning independently of the context, it is unclear what conditions students think about when reporting their behaviour. This situation can cause problems in relation to the interpretation and generalisation of self-report data, since the conditions are likely to differ among students (Perry & Winne, 2006). Furthermore, even though many self-report measures attempt to establish a context such as asking students to think about a particular domain or course while answering questions, their responses may reflect their behaviour on only some noticeable occasions rather than presenting it across similar instances (*ibid*).

Another important limitation referred to by Perry and Winne (2006) is related to the question of how accurately students perceive how they study. Supporting this view, previous research indicates that learners are not often good at calibrating their thoughts and action accurately (Hadwin *et al.*, 2007; Winne *et al.*, 2002). This is true especially when the information required cannot be retrieved from memory, or is altered as a result of memory search that is often more of a constructive process than

a retrieval one (Perry & Winne, 2006). Consequently, when students report the properties of their actions, they may rely on intuitions to assess them. Thus, when answering self-report instruments, it is possible that students may misinterpret the properties of their regulation of learning processes or give inaccurate information about the frequency of the processes which they actually engage in during the learning process (Winne *et al.*, 2002).

As a result, the use of self-report measures to study the regulation of learning processes is increasingly recognised as being inadequate for revealing what students actually do during learning or how the characteristics of a specific learning context can influence what they actually think and do (Perry, 2002).

Recently, most contemporary researchers have conceptualised the regulation of learning as a series of events which dynamically unfold and change over time within a particular context (e.g., Azevedo *et al.*, 2010; Butler, 2011; Turner, 2006; Zimmerman, 2008) and constitute both individual and social processes (e.g., Butler, 2011; Hadwin & Järvelä, 2011; Volet *et al.*, 2009a). In contrast to measuring SRL processes as an aptitude by using self-report instruments at a single point in time, this conceptualisation reflects a more qualitative approach and calls for studying students' regulation of learning as an ongoing dynamic and developing process while occurring in real time and real contexts, as well as focusing on both individual and social processes involved in the regulation of learning (Butler, 2011; Hadwin *et al.*, 2011; Perry & Rahim, 2011). A variety of alternative instruments have been suggested to measure the regulation of learning as an event concurrently during learning, such as think aloud protocols, traces, video stimulated-recall interviews, and direct observations (Boekaerts & Corno, 2005; Johnson *et al.*, 2011; Winne & Perry, 2000; Zimmerman, 2011).

For think aloud protocols, students are invited to verbalise their thoughts, feelings and other cognitive processes while performing a learning task (Boekaerts & Corno, 2005; Winne & Perry, 2000). This method is considered as having the advantage of providing more accurate and objective data, since it captures students' ongoing thoughts and feelings concurrently while they are learning, rather than recalling or reporting their actions after performing the task (Boekaerts & Corno, 2005). Also, due to its open-ended nature, it allows them the freedom to verbalise various aspects

of self-regulation processes (Greene *et al.*, 2011). Previous research studies have successfully utilised think aloud protocols to identify students' cognitive and metacognitive regulation processes, mostly in computer-based learning environments (CBLEs) (e.g., Greene & Azevedo, 2007a; Bannert & Mengelkamp, 2008; Moos & Azevedo, 2009), but there has been no study looking at the motivational and emotional regulation processes by this method to date.

There are some concerns in relation to the use of this approach. The first relates to the influences of think aloud protocols on students' cognitive system, for it is unclear whether it disrupts their learning processes or not (Moos & Azevedo, 2008). For instance, asking students to describe or explain their cognition may affect the types of cognitive and metacognitive processes they enact (Boekaerts & Corno, 2005). Another criticism is regarding the problem of consciousness (Bannert & Mengelkamp, 2008). That is, when using think aloud protocol, learners can only verbalize conscious processes (Ericsson & Simon, 1994), whilst unconscious ones that occur during learning always remain concealed and unmeasured. Furthermore, this method is seen as challenging especially for younger children, since they may not have the verbal ability needed to describe their mental processing successfully (Boekaerts & Corno, 2005; Wolters *et al.*, 2011). Lastly, the use of think aloud protocols is not suitable for many authentic learning situations (e.g., classrooms) (Wolters *et al.*, 2011) or for investigating the social aspects of regulation of learning, because the data is usually collected from individual students in individual learning situations.

Trace logs have been also used to measure the regulation of learning processes concurrently during learning. These are defined as observable indicators of cognitive activities that students create while engaging in a task (Winne & Perry, 2000; Zimmerman, 2008). According to Perry and Winne (2006), traces can provide 'accurate, time-referenced descriptions of observable interactions between learners and content' (p.216). Several researchers have successfully utilised trace data to gain insight into students' regulation of learning (e.g., Hadwin *et al.*, 2007; Manlove *et al.*, 2009; Perry *et al.*, 2010; Saab *et al.*, 2011). In one recent study carried out by Perry and colleagues (2010), first grade students learnt about the lifecycle of frogs by means of using the gStudy software which provided trace data in relation to various

types of SRL processes they engaged in. In another example study, Janssen *et al.* (2010) investigated how secondary school students collaborated in a CBLE, called the Virtual Collaborative Research Institute (VCRI), which allowed the students to communicate with one another, access different sources of information, and co-author texts or essays. In their study, all communication and online interactions among group members were logged via the VCRI software and analysed with the purpose of identifying task-related and social regulation processes.

In general, traces are seen as advantageous, especially when used with younger children, since the data collected does not rely on participants' verbal abilities and can be easily collected especially in CBLEs (Perry & Winne, 2006; Wolters *et al.*, 2011). However, as Wolters *et al.* (2011) point out, traces require well-designed experimental tasks, and hence are usually difficult to apply to actual classroom settings. Also, the use of this approach requires many students to have access to and understanding of computers and specific software programmes. Furthermore, the validity of the findings is also questionable, since the trace data provides less information about the reasons for students' behaviours and actions during learning.

Another instrument, stimulated-recall is a special form of interview that invites participants to recall and reflect on their actions, thinking and feelings, often while watching video episodes of themselves performing a task or activity (Boekaerts & Corno, 2005; Winne & Perry, 2000). It has been successfully used in previous studies to capture various aspects of students' regulation of their learning processes (e.g., Iiskala *et al.*, 2004; Moschner *et al.*, 2008; Nielsen *et al.*, 2009). Stimulated-recall interviews typically provide open-ended, qualitative data in which students describe and interpret their actions, thinking, feelings and interactions in their own words as well as from their own perspectives. Also, they can provide insights into unobservable aspects of their regulation processes. Nevertheless, akin to the think aloud protocol, the quality of data collected during stimulated-recall interviews depends on participants' verbal abilities.

Direct observations of performance also provide a concurrent measurement of students' regulation of their learning processes. That is, they provide the opportunity to record and analyse participants' behaviour and social interactions while occurring

in naturalistic settings (Boekaerts & Corno, 2005; Ritchie, 2003). A number of advantages have been mentioned in relation to the use of observations. According to Winne and Perry (2000), they are advantageous since they reflect what students actually do versus what they recall or believe they do; allow establishing links between students' use of regulation processes and the features of learning context or task conditions; and are particularly helpful for examining younger students' regulation of learning as they do not depend on the verbal or writing abilities of the participants. Moreover, in addition to these advantages, Whitebread and colleagues (2009) point out two further benefits. First, observations, especially when video recording is involved, provide the researcher with the opportunity to record both verbal and non-verbal behaviours. Second, a further benefit of this method is related to the opportunity to record social processes, such as collective interactions and collaboration among students, in naturalistic classroom settings. Hence the use of observational data makes it possible to see a full spectrum of students' regulation of their learning processes with an integrated focus of both the self and social perspectives.

As previous studies have evidenced, observations have been demonstrated to capture effectively self and social forms of metacognitive, motivational and emotional processes in naturalistic learning situations (e.g., Järvelä *et al.*, 2010; Perry *et al.*, 2002; Whitebread *et al.*, 2007, 2009). However, despite its benefits, direct observation also has some limitations. For example, only directly observable behaviours and interactions can be identified with the use of this approach, while covert mental processes of participants usually remain unassessed (Veenman *et al.*, 2006; Whitebread *et al.*, 2009). Also, similar to trace methodology, observations offer less information than some of the other available data collection methods about the reasons for students' behaviours and actions (Wolters *et al.*, 2011). Moreover, high demands are placed on the researcher's time and effort for the collection and analysis of observational data (*ibid*).

As the above review illustrates, most of the instruments which measure the regulation of learning concurrently during the learning process seem to have a number of advantages over self-report measures, since they allow for the investigation of students' regulation of their learning processes as they occur in real

time in relation to a particular learning contexts, rather than relying upon what students think or say what they do. Furthermore, these instruments, particularly direct observations, stimulated-recall interviews, and traces, appear to be suitable for investigating self and social forms of regulation processes, as they can allow collection and analysis of various types of data at both the individual and social levels.

Nevertheless, it is also widely acknowledged by most contemporary researchers that no single instrument can sufficiently measure the components of students' regulation of their learning (e.g., Azevedo & Strain, 2011; Boekaerts & Corno, 2005; Butler, 2011; Cascallar *et al.*, 2006; Järvelä *et al.*, 2010; Perry & Rahim, 2011; Veenman, 2005; Zimmerman, 2008). Thus, it is considered important to use multiple data collection and analysis techniques in order to explore the various aspects of regulation of learning processes adequately. In line with these arguments, the aim in this current study is to investigate students' self and social regulation of their learning as a dynamically unfolding and changing process over time within a particular learning context, through utilising multiple measurement instruments.

Having reviewed the literature concerning the current theoretical and methodological perspectives in the study of self and social regulation of learning, and the regulation of learning research on scientific inquiry learning, in the following chapter, I focus on the methodology and the research design used to explore the research questions of this current thesis.

Chapter 3 – Research Methodology and Design

3.1 Introduction

Considering the discussions in Chapter 1 and 2, this thesis aims to investigate how Turkish upper primary school students (aged 12, grade 7) self and socially regulate metacognitive, motivational and emotional aspects of their learning in the context of whole class and small group scientific inquiry activities. In order to achieve this overarching goal, this study focuses on the following research questions:

- 1 Do students use self-, co-, and shared regulation of metacognitive, motivational and emotional processes during scientific inquiry activities, and if so, what relationship exists between the types of these regulation processes?
- 2 How does students' use of regulation of learning processes change over time across the sequence of whole class and small group activities?
- 3 How do social forms of metacognitive regulation processes emerge and function in the context of scientific inquiry activities?

In this chapter, the methodological approach that informs this thesis is explained and justified. Firstly, the qualitative approach and epistemological assumptions guiding this study are presented (Section 3.2). Next, the use of case study as a method of investigation for this thesis is described (Section 3.3). This is followed by an explanation of the research design, including a description of the sampling procedure and research context (Section 3.4). Subsequently, the data collection and analysis processes will be described (Sections 3.5 and 3.6), prior to discussion of the techniques used to enhance the trustworthiness of this research and the ethical issues considered in the design and conduct of this study (Sections 3.7 and 3.8). Finally, the research methodology and design will be summarised in Section 3.9.

3.2 A qualitative research approach

As this current thesis aims to investigate Turkish upper primary students' regulation of learning as both an individual and social process, dynamically unfolding and changing over time within a particular learning context, the adoption of a qualitative approach that focuses on describing these processes in detail in a naturalistic classroom setting is considered to be consistent with the purpose of this study.

A qualitative research approach aims to provide 'an in-depth and interpreted understanding of the social world of research participants by learning about their social and material circumstances, experiences, perspectives and histories' (Snape & Spencer, 2003, p.3). It is commonly associated with the interpretive research paradigm which aims at understanding 'the subjective world of human experiences' (Cohen *et al.*, 2000, p.22). According to the interpretive perspective, reality is considered socially constructed by individuals interacting with a social context (Merriam, 2009). This perspective, hence, implies that there are multiple realities, instead of recognising the existence of a single, unique one (Schwandt, 1998). This paradigm also assumes a subjectivist epistemology which suggests that the researcher and the subject are interactively linked and create knowledge together that is transactional and subjective in nature (Guba & Lincoln, 1994), as opposed to the positivist paradigm, under which it is claimed that it is possible to obtain information about the social reality in an objective and detached manner (Cohen *et al.*, 2000; Denzin & Lincoln, 2000). Methodologically, the interpretivist approach suggests that the participants' constructions are elicited and refined through interaction between the researcher and the participants within the process of the research. In this view, the inquirer is involved in interpreting and constructing an understanding of the constructions of the participants (Plack, 2005; Schwandt, 1998). Having adopted a qualitative interpretivist approach for this research, this shapes the nature of the collection, analysis, interpretation and understanding of the data. That is, in this study, reality is considered to be socially constructed and the aim is to look for meaning from the participants' perspectives and their actions.

As a naturalistic, interpretive approach, qualitative research tends to 'place emphasis and value on the human, interpretive aspects of knowing about the social world and

the significance of the investigator's own interpretations and understanding of the phenomenon being studied' (Snape & Spencer, 2003, p.7). It is usually used when addressing research questions that entail understanding or explanation of social phenomena and their contexts. Also, in contrast to quantitative research, it can provide detailed and information rich data through data collection tools which are sensitive and flexible to the social context in which the data are produced (Mason, 2002). Moreover, the researcher is seen as the primary instrument during data collection and analysis, who can respond to 'the situation by maximising opportunities for collecting and producing meaningful information' (Merriam, 1998, p.20). As qualitative research usually explains and presents phenomena as experienced by the research participants in naturalistic settings, in detail and from their perspectives, it presents opportunities 'to unpack issues, to see what they are about or what lies inside, and to explore how they are understood by those connected with them' (Ritchie, 2003, p.27). Further, such research almost invariably relies upon an inductive research strategy, which is open to emerging ideas and concepts and 'may produce detailed description and classification, identify patterns of association, or develop typologies and explanations' (Snape & Spencer, 2003, p.5).

Taking into account the aforementioned characteristics, the qualitative research approach is well suited for addressing the research questions of this thesis. According to Patrick and Middleton (2002), it is seen as appropriate when answering 'what, how, why and when' questions in the regulation of learning research, as it can provide rich holistic descriptions, emphasise the social setting in which the investigated phenomenon is situated, and can reveal complexity. A qualitative investigation of self and social regulation of learning during naturally occurring scientific inquiry activities, hence, can provide rich, contextualised information on how students regulate their solo and joint learning, explain how their regulation of learning changes across contexts and across time, as well as identify how the features of scientific inquiry learning context influence this regulation. Accordingly, as the research questions of this study seeks an in-depth exploration of how students regulate self and social aspects of their learning processes in a naturalistic classroom setting, rather than identifying the effects of one or several variables on their learning in experimental or manipulative settings, which would probably entail a quantitative

positivist research perspective, a qualitative, naturalistic approach is deemed to be appropriate for this current study.

3.3 Case study research method

Under the qualitative research umbrella, there are a variety of research methods that can be employed to provide an exploration of complex phenomena in educational research settings (Creswell, 2003; Freebody, 2003). In this thesis, a qualitative case study research approach was chosen in order to attain an in-depth investigation of Turkish upper primary students' self and social regulation processes in a naturalistic classroom setting over time (Butler, 2011; Creswell *et al.*, 2007; Yin, 2003). Supporting this, case study research is generally defined as 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident' (Yin, 2003, p.13). As a qualitative research strategy, it focuses on an in-depth investigation of an individual or a group as an entity over time within authentic settings (Creswell, 2007; Yin, 2003). Its use is usually viewed appropriate when the inquiry focus is to answer 'how' and 'why' questions to understand complex social phenomena over time (Yin, 2003). It is also suitable for those research situations which involve many variables of interest, utilise multiple sources of evidence (Stake, 2005; Yin, 2003), and those that employ the prior development of theoretical propositions to guide the collection and analysis of data (Yin, 2003). Furthermore, because case study research is conducted within a naturalistic setting through using multiple data sources it can provide a rich and holistic understanding of the phenomenon being studied (Creswell *et al.*, 2007; Merriam, 1998; Patton, 2002).

Being embedded within a naturalistic, interpretive inquiry, the qualitative case study approach is not concerned with the generalisability of findings to a wider population as in statistical research, but rather it advocates 'naturalistic generalisation' by the readers who can assess the relevance of the research findings to new circumstances (Stake, 1988) or 'analytic generalisation' in which the research findings are used to inform, build or elaborate upon a set of theoretical concepts, principles or propositions for more general applications in other circumstances (see Butler, 2011; Lewis & Ritchie, 2003; Yin, 2011). Moreover, since the data of qualitative case

studies are constructed through the interactions between the researcher, participants and context, it is important for the foremost to reflect on their own positions and personal processes concerning the phenomenon under study, a stance usually termed reflexivity (Creswell, 2003; Mason, 2002).

Considering its characteristics, the qualitative case study approach appears to be well suited with the aims of this study. As explained in Section 2.6, the incorporation of multiple sources of data is important for providing a more accurate measurement of various aspects of self and social regulation of learning as they occur in real time within a naturalistic classroom context. In adopting a case study approach, this offers a rigorous inquiry frame which justifies coordinating multiple data sources to understand better the complex nature of a phenomenon, here self and social regulation of learning, in the context in which it is found (Butler, 2011; Yin, 2003). Moreover, this study is interested in studying students' self and social regulation of metacognitive, motivational and emotional processes as a dynamic and recursive event over time. In this respect, the case study method presents a useful inquiry frame since it allows for studying the complexity of issues and processes occurring overtime within naturalistic settings (Merriam, 2009; Yin, 2003).

Alternative qualitative methods, such as a solely interview based approach, which relies on a single source of data or ethnographic research, which is 'grounded in a commitment to the first-hand experience and exploration of a particular social or cultural setting on the basis of (though not only exclusively by) participant observation' over a longer time period (Atkinson *et al.* 2001, p.4) were considered as being inappropriate for attaining the aforementioned aims of this thesis. That is, it was deemed that the former would be hindered by the limited insight of the participants regarding their learning (as discussed in Section 2.6), whilst the latter was impractical given the fieldwork time restrictions.

There are different types of qualitative case studies which can be utilised depending on the overall research aims (Creswell, 1998; 2007), and according to Stake's (1995) categorisation, they can be intrinsic, instrumental or collective. In an intrinsic case study, the focus is on the case itself due to an unusual or unique situation the case presents to the researcher, whereas for an instrumental case study, the researcher focuses an issue or phenomenon and chooses a bounded case to describe it. During a

collective or multiple-case study, the focus is again on an issue, phenomenon or concern but it is studied through selecting multiple cases. A number of researchers highlight the advantages of using multiple-case studies over a single case study design. For instance, according to Yin (2003), a multiple-case study design enables a replication of the findings across cases through either predicting similar results or contrasting ones for predictable reasons. The use of multiple-case study design can also be cumulative in nature, which gives the researcher the possibility of building up information from several cases and/or sub-cases, thereby enhancing the robustness and reliability of the research (Freebody, 2003). Furthermore, a practical advantage of a multiple-case study is that if one of the cases drops out, the researcher can still have others through which to carry on his/her research. Regarding the type of case study adopted for this research, whilst the initial intention in the research design was to include multiple case classrooms, in the event, only one fully participated in the research and as a result, an instrumental case study was employed, given that the focus was on every day occurring events.

3.4 Research design

This section illustrates the research design of this study, with a description of the pilot study phase, the procedures used to gain access to the participants, the strategies used to select the case sample, and the context of this research (see Figure 3.1 for a summary of the research design).

3.4.1 Pilot study

After obtaining ethical approval both from my own university and the Turkish Ministry of National Education, during May 2010, several schools in Ankara, the capital of Turkey, were randomly identified via an Internet search. After making sure that the scientific inquiry learning approach was being used in these schools in accordance with the national curriculum, they were invited to participate in the pilot phase of this study, with the purpose of testing the feasibility of the initial research design as well as improving the quality and efficiency of the main study phase.

After one of the public primary schools showed a willingness to participate, I sent the information sheet and consent forms to the science teacher of one class of sixth grade

students (aged 12) and their parents for them to sign and return. Once this was obtained from all the participants, a meeting was arranged with the teacher and she was provided with more detailed information about the purpose of the pilot study as well as the data collection procedure. Also, she was asked to select two students to be focused upon during lesson observations based on their science achievement level (one high and one low-achieving) and anticipated willingness to share their thoughts with the researcher.

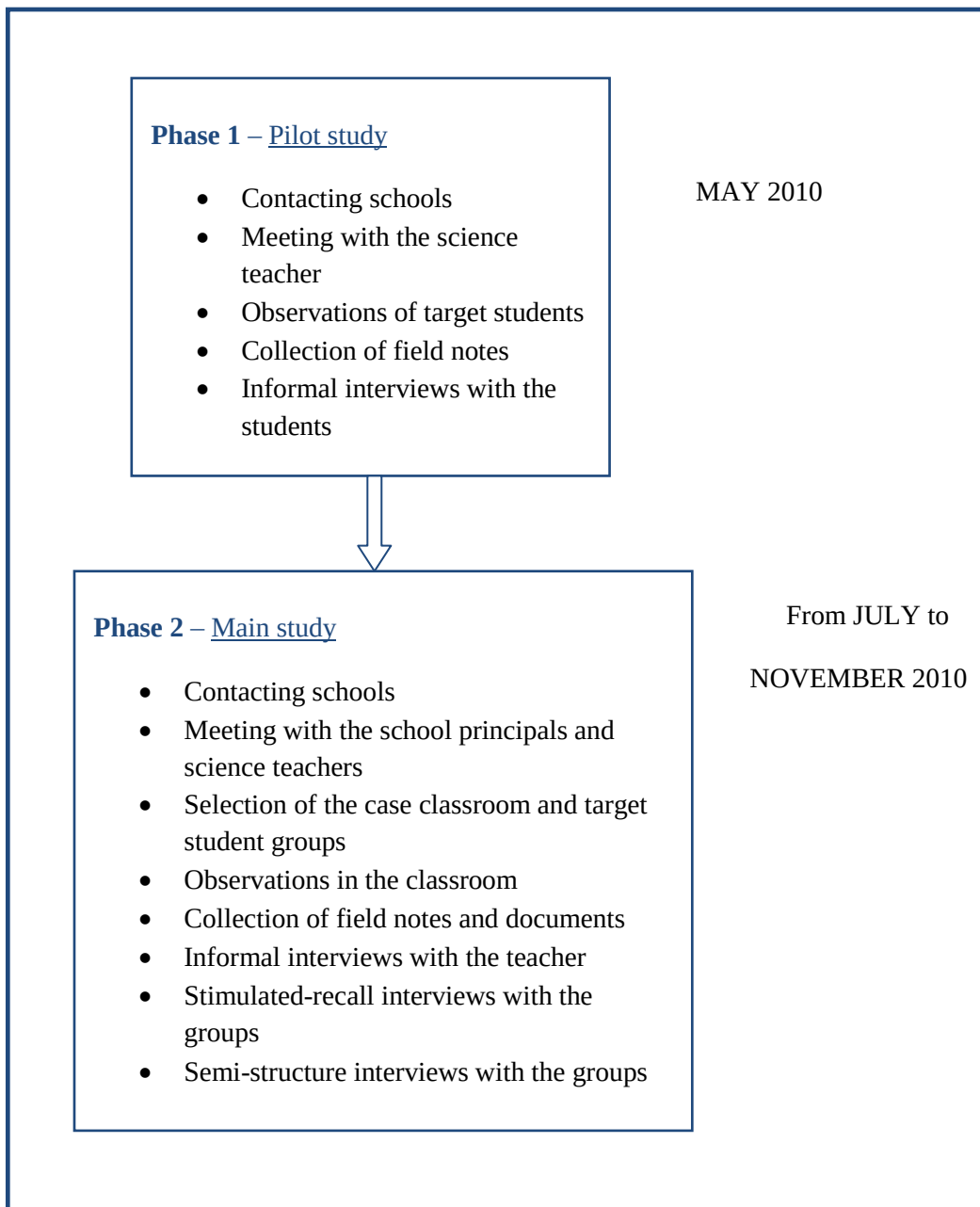
Each of the chosen students was video recorded and observed during three of their science lessons. Moreover, field notes were taken during these lesson observations. While the initial design of this pilot phase also included conducting stimulated-recall and semi-structured interviews with the target students and teacher, owing to their full timetable, I was only able to carry out some informal interviews with the students during the break times concerning their perspectives on their engagement in science lessons. The observational video data was analysed in order to gain an insight into the students' use of self-, co-, and shared regulation of their learning processes. In addition, the interview data and field notes were used to characterise the nature and context of the scientific inquiry activities observed.

The pilot study phase was useful in helping me become more familiar with the research context and refining the data collection procedures for the main study phase. Moreover, its outcomes resulted in several important adjustments being made in relation to the initial research design. Firstly in this regard, it emerged that the students were engaging in both whole class and small group inquiry activities in line with the curriculum guide book. Also, they were observed to engage in social forms of regulation processes mostly while interacting with their peers during small group activities. Hence for the main study phase, in order to have a better understanding of how students engage in social forms of regulation processes, it was considered more appropriate to focus on the group as a whole rather than individual students within it.

Secondly, since it had not been possible to carry out stimulated-recall and semi-structured interviews with the students and the teacher, for the main study phase, it was decided to select and work with participants who could devote considerable amount of time for this study. Finally, the use of camcorders and tripods during the

piloting phase appeared to obstruct the usual classroom practices given the small classroom setting. Hence it was deemed important that a classroom(s) of ample size should be chosen for the main study. The next section describes the procedures used to gain access to the participants of the main study and the sampling strategies employed.

Figure 3.1 – Summary of the research design



3.4.2 Sampling procedure and participants

In comparison with the quantitative research which typically utilises random sampling strategies for obtaining statistically representative sampling (Ritchie *et al.*, 2003a; Robson, 2002), the sampling process in qualitative studies is usually concerned with selecting a sample from which the most can be learned (Merriam, 2009; Stake, 1995). Sampling in qualitative research is an important issue, because the procedure chosen to identify, select, and acquire access to appropriate data sources should result in an optimal sample being recruited (Merriam, 2009; Mason, 2002). For this current study, a two-level sampling was utilised which involved first selecting the case classroom, and then identifying the student groups to be focused on within it. The sampling procedure utilised was non-probabilistic involving purposeful sampling strategies (Bryman, 2012; Mason, 2002; Ritchie *et al.* 2003a), which according to Patton (1990) involves ‘selecting information-rich cases for study in-depth’ and ‘information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research’ (p.169). In line with this view, the selection of the case classrooms and participants were guided by such purposeful criteria.

Selection of the case classroom

Since all primary schools in Turkey are subject to the Ministry of National Education and legally required to follow the new primary science and technology curriculum, it was decided to contact both public and private primary schools to take part in the main phase of this study, with the purpose of maximising the chance of gaining access to multiple classrooms and participants. During July 2010, in line with the multiple-case study design, I sent the principals of a number of public and private primary schools in Ankara emails containing information about my research project and asked for permission to conduct research in their schools. Similar to the pilot study phase, these schools were identified through an Internet search and were reported to be using the scientific inquiry approach in science lessons in accordance with the national curriculum. Among the schools contacted, one public and one private school showed a willingness to participate in this study.

Once access was gained, the science teachers in these schools were emailed an information sheet, which included an explanation of the purposes of the research and a consent form regarding their participation. Taking into consideration the experiences from the pilot study phase, the teachers were also asked if they were actively using the inquiry learning approach and small group activities in their lessons as recommended by the new science and technology curriculum, and whether their students would feel confident when being video recorded in their lessons as well as have enough time to be interviewed. After receiving positive feedback from the science teachers, an introductory meeting was arranged with the school principals and science teachers in each school in order to provide them with more details about the characteristics of the research as well as to discuss the practical issues, such as the use of camcorders in the classrooms observations and the interview time schedules.

Unfortunately, prior to the start of data collection, the teacher from the public school withdrew his participation owing to his decision to take up a place on a new professional development programme in the school. Therefore, whilst the original intention was to have multiple case classrooms participating in this study, in the event, there was only one teacher, Mrs. Celin who agreed to take part with her class.

The school participating in this study was a private primary school located in the city centre of Ankara. Similar to many other private schools in Turkey, it was a fee paying school, and unlike to be found in public primary schools, almost all students were from higher socioeconomic backgrounds. As mentioned above, like all other primary schools in Turkey, it was subject to the Ministry of National Education and legally required to follow the national primary curriculum. Also, as is typical in other primary schools, a class-teacher system applies for the first five grades, where class teachers usually teach all lessons, with the exception of English, Music and Sports, while all the lessons at the upper primary stage (grades 6 to 8), which is the focus of this study, are taught by subject specialists. There were three classes for each grade in this school and the average class size was approximately 22, relatively similar to other private and public schools in Ankara. Being a science teacher with eight years experience, Mrs. Celin had been working in this school since 2006 and teaching the new science and technology curriculum at the upper primary stage since that time.

Since scientific inquiry learning approach was being used first time at the upper primary stage in this school, it was decided to focus on one of the classrooms from this stage. After having a conversation with Mrs. Celin, her seventh grade classroom was chosen as the case for this study, the second and middle year of the upper primary school stage, since the students in this grade were already used to being taught by a subject specialist science teacher as compared to the 6th grade students who had just been transferred from a class-teacher system, and the former were not preparing for the end of year national examination as much as the eighth grade students were doing. On the first day of the academic year, I was introduced to Mrs. Celin's students and provided them with detailed information about the purpose of my research. Then, I asked all of them to give their parents an information sheet and consent form to sign regarding participation in the study, which was obtained before the second science lesson of the year during which the data collection started.

Table 3.1 – Target student groups

Name of students	Sex	Science achievement level	Group name
Leman	Female	High-achiever	Group A
Kutay	Male	Mid-achiever	Group A
Ayşe	Female	Mid-achiever	Group A
Ezgi	Female	High-achiever	Group B
Brus	Male	Mid-high achiever	Group B
Vural	Male	High-achiever	Group B

*Note: All the names used in thesis are pseudonyms.

Selection of the student groups

In their first science lesson, Mrs. Celin asked her students (aged 12, n=24) to self-select groups of three for the small group activities they would undertake in their science lessons in accordance with the criteria of having mixed groups containing

boys and girls as well as differing science achievement levels. Whilst the initial intention of the research design had been to focus on only one student group from each participating classroom, as there was only one case classroom participating in the research, it was decided to focus on two groups as mini cases (Stake, 2006) in order to acquire a more insight into students' regulation of learning processes than were it otherwise (see Table 3.1 below).

The student groups were selected by the teacher using criteria that we decided upon together, including willingness to be video recorded and interviewed, having good group work skills as well as good attendance of all members. The students in both case groups worked together throughout the first unit and were video recorded for both whole class and small group scientific inquiry activities during the first unit of the curriculum. Moreover, stimulated-recall and semi-structured interviews were carried out with the members of these student groups.

3.4.4 Description of the instructional context

In qualitative case studies, it is important to provide a description of the research context, as each case is situated and is expected to influence as well as be influenced by this particular context (Stake, 2006). Hence this subsection presents an overview of the instructional setting in which this study was carried out.

In 2005, as a part of major primary school curriculum initiative, the Turkish Ministry of Education and Board of Education introduced the new science and technology curriculum for primary education grades 6 to 8 (MoNE, 2006). Its stated vision is to raise scientifically literate students regardless of their individual differences in order to prepare them for the challenges of 21st century. More specifically, in order to attain scientific literacy, students are expected to develop scientific inquiry, critical thinking, problem solving, and communication skills. In addition, they were expected to become lifelong learners as well as acquire necessary attitudes, values, understanding and knowledge for maintaining a sense of curiosity concerning science, the environment, and the world.

The learning areas in the new curriculum include 'physical processes', 'life and living beings', 'matter and change', 'the earth and the universe' (MoNE, 2006; Tasar

& Atasoy, 2006). Throughout the curriculum, students are expected to take on more responsibility in their learning process, and to acquire and use science process skills, develop an understanding of the relationship between science, technology, society and environment, as well as gaining positive attitudes and values towards science while learning each of the content units. As a facilitator of students' learning, teachers are recommended to utilise multiple assessment and evaluation techniques, such as performance assessment, portfolios, concept maps, peer evaluation and presentation.

Being based on a constructivist learning approach, the new science and technology curriculum also puts special emphasis on scientific inquiry learning (MoNE, 2008). In the curriculum, the 5E learning cycle is used to organise and sequence all the lessons and learning activities around the principles of this approach. That is, this model includes engagement, exploration, explanation, elaboration and evaluation phases which are assumed to engage students actively in the scientific process and help them construct new scientific understanding over time. By using student-centred learning activities sequence based upon the 5E inquiry cycle, teachers are expected to create an optimal learning environment in which students can actively construct their understanding of scientific concepts through inquiry, real world exploration, and collaboration (MoNE, 2008). This new science and technology curriculum is now being used in all public and private primary schools in Turkey, with several adjustments having made to its content each year according to the changing needs of students and teachers.

Mrs. Celin followed the new science and technology curriculum, while she also made some adjustments in relation to the small group learning activities. She was positive about and comfortable with teaching through the new curriculum. All the learning activities observed in this study took place in the same science and technology classroom between September and November 2010 (see Figure 3.2 for the classroom layout). The data collection was carried out during the first unit of the curriculum on *human body systems*, which comprised three main topics, namely the digestive system, the nervous system and the excretory system. This unit covered 17 lessons lasting for a seven week period.

Mrs. Celin used a similar sequence of activities for each science topic of this first unit of the curricula (see Appendix B for the sequencing and duration of the activities). That is, in line with the engagement phase of 5E inquiry cycle, each science topic began with an introductory session in which the teacher probed the students' preconceptions, and aimed to create interest and curiosity in relation to the science topic under consideration, in particular, by asking them to think about some of the key concepts through a whole class dialogue.

Following each introductory session, consistent with the exploration and elaboration phases of 5E inquiry cycle, the students were asked to observe and take notes from video clips of real life events and animated drawings, which were subsequently used to address collaboratively a set of inquiry questions during small group activities. During these group activities, they were expected to engage actively in scientific inquiry processes by jointly analysing and considering the various types of information they had collected, sharing and negotiating each other's ideas, and co-constructing new scientific understanding as a group (MoNE, 2008). Moreover, at the start of each small group work session, they were provided with both written and verbal instruction about the objectives and principles of the small group activities by Mrs. Celin. All the group tasks were related to their everyday lives, encouraged seeking more than one answer or ideas, and were designed to become progressively more difficult towards the end of the unit.

In line with the explanation and evaluation phases of the inquiry cycle, teacher-guided, whole class discussions took place after each small group activity in order to present the students with opportunities to explain and extend their understanding of the scientific concepts and topics through engaging in dialogue with their peers and the teacher. During these discussions, the teacher's goals were to assess their understanding and explanations, pose new questions and problems, and to encourage them to communicate and negotiate their ideas with others in the class (MoNE, 2008). Table 3.2 provides objectives of the scientific inquiry activities observed in the current study (also, see Appendix C for a sample lesson plan and group activity worksheets).

Figure 3.2 – The layout of the science and technology classroom

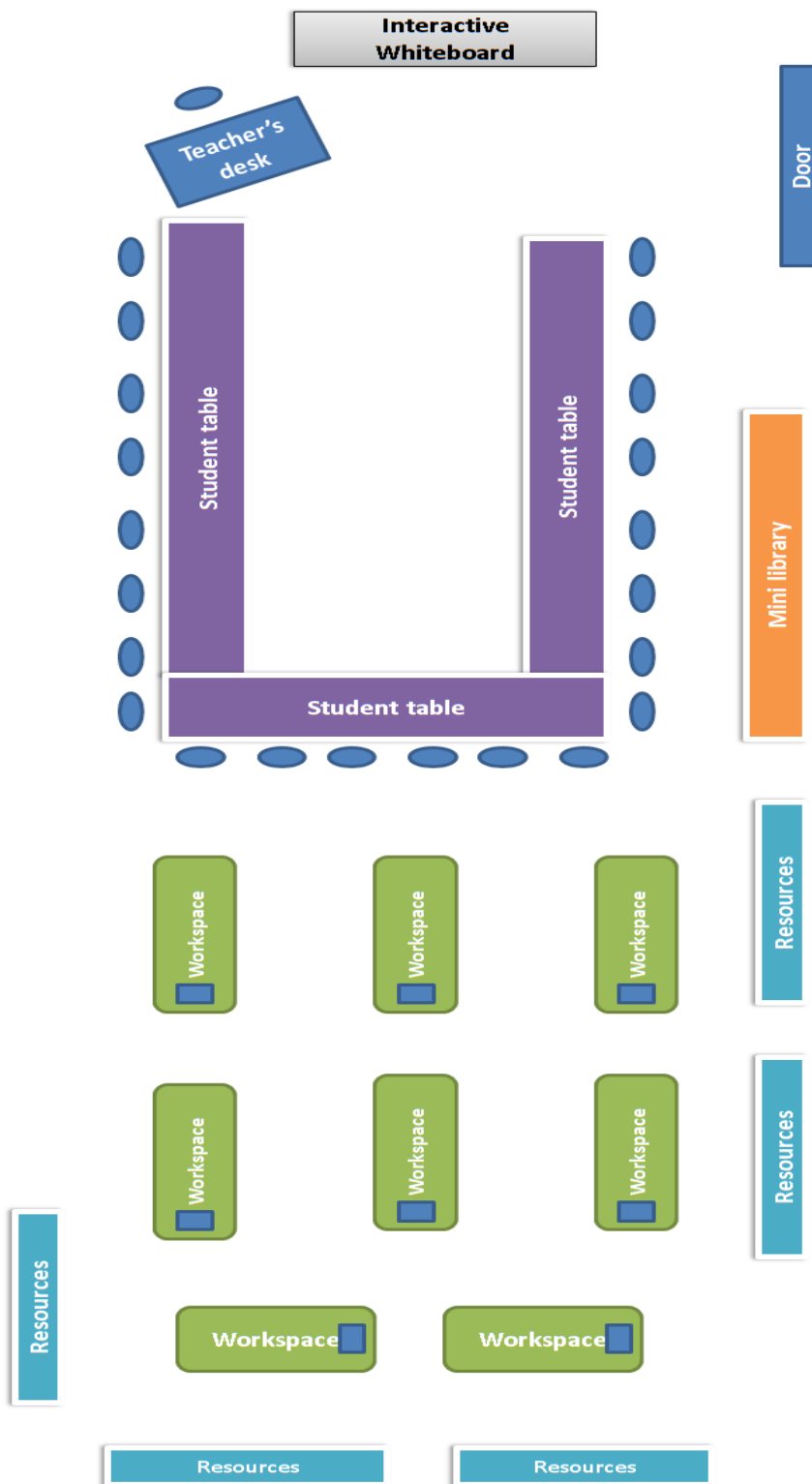


Table 3.2 – Objectives of the scientific inquiry activities according to Mrs. Celin’s unit plans

Learning activities	Goals of the activity (Students should...)
<i>Digestive system</i>	
Introductory activity 1	- Recall his/her prior knowledge about the types of nutrients and their functions in the human body - Discuss and reflect on the following key concepts: physical digestion, chemical digestion, enzymes, and absorption - Develop interest and curiosity towards the subject of the digestive system
Small group activity 1: ‘Why do we eat?’	- Understand that the structure of the nutrients needs to undergo changes in order to be used in the human body - Understand the relationship between the nutrients and the energy produced and used in the human body
Whole class discussion 1	- Share, explain, assess and extend his/her understanding with his/her peers and the teacher through a whole class dialogue

Small group activity 2: ‘Journey of food’	- Identify and explain the role of digestive system organs in the human body - Develop understanding of the functions of digestive enzymes and assistive organs during the digestion process - Understand and explain how the nutritional content of carbohydrates, fats and proteins are digested and absorbed into the bloodstream - Understand and explain how water, vitamins and minerals are absorbed into the bloodstream, and for what purpose they are used in cells
Whole class discussion 2	- Share, explain, assess and extend his/her understanding with his/her peers and the teacher through a whole class dialogue
<i>Nervous system</i>	
Introductory activity 2	- Think about how the events occurring in the human body take place - Discuss and reflect on the following key concepts; neuron cell, gland, and hormone - Develop interest and curiosity towards the subject of the nervous system
Small group activity 3: ‘Football match’	- Understand and explain the role of the nervous system in the harmony and coordination existing among the human body systems
Whole class discussion 3	- Share, explain, assess and extend his/her understanding with his/her peers and the teacher through a whole class dialogue

Small group activity 4: ‘The poisonous plant’	- Understand and explain how the nerve messages transmission occurs in the human body - Understand how certain events occurring in the human body are controlled and coordinated by the brain or by the spinal cord as a reflex
Whole class discussion 4	- Share, explain, assess and extend his/her understanding with his/her peers and the teacher through a whole class dialogue
<i>Excretory System</i>	
Introductory activity 3	- Think about the role and importance of kidneys in the human body - Discuss and reflect on the following key concepts; nephron and dialysis - Develop interest and curiosity towards the subject of the excretory system
Small group activity 5: ‘Water content of our body’	- Understand and explain how the regulation of water concentration takes place in the blood - Understand the roles of the brain, endocrine glands and kidneys during the filtration of blood - Articulate and reflect on the problems the human body face in case of disorders in the excretory system
Whole class discussion 5	- Share, explain, assess and extend his/her understanding with his/her peers and the teacher through a whole class dialogue

3.5 Data collection tools

In line with the suggestions concerning the need for studying students' regulation of learning processes as a series of unfolding events in real time within naturalistic contexts as well as through utilising multiple sources of qualitative evidence (e.g., Azevedo *et al.*, 2010; Butler, 2011; Cascallar *et al.*, 2006; Perry & Rahim, 2011; Winne & Perry, 2000; Zimmerman, 2008), the data of this study included classroom video observations and stimulated-recall interviews with two student groups of three, which allowed for concurrent measurement of their regulation of learning processes during scientific inquiry activities. Considering the dynamic and complex nature of regulation processes, additional data were also collected by means of semi-structured interviews with the students, informal interviews with the teacher, field notes, as well as samples of student worksheets and lesson plans. That is, these had the aim of providing further insights into understanding the nature of students' regulation of their learning processes. The triangulation of multiple sources of data is also seen as key for achieving a comprehensive understanding and producing a valid analysis of students' self and social regulation of learning processes within the social context (Järvelä *et al.* 2010; Volet *et al.*, 2009a). The next sections describe each of the data collection techniques and procedures.

3.5.1 Observations

Observation refers to 'the opportunity to record and analyse behaviour and interactions as they occur' in naturalistic settings (Ritchie, 2003, p.35). As one of the primary sources of data in qualitative research, it is viewed as being particularly useful 'when a study is concerned with investigating a "process" involving several players, where an understanding of non-verbal communications is likely to be important or where the behavioural consequences of events form a focal point of study' (*ibid*, p.35). As the focus in this thesis rests on investigating upper primary students' self and social regulation of their learning processes as a dynamic and recursive event in a naturalistic, educational setting, it was decided that observation was to be the principal strategy for the data collection.

As mentioned in Section 2.6, the use of observations has a number of advantages in relation to the measurement of students' regulation of their learning processes.

Firstly, they are useful because they reflect what the students actually do as opposed to what they recall or believe they do; allow establishing links between students' regulation of learning processes and the features of learning context or task conditions; and are particularly helpful for examining younger students' regulation of learning as they do not depend on the verbal or writing abilities of the participants (Winne & Perry, 2000). Also, in addition to being able to record verbal and non-verbal behaviours, observations permit recording and analysing the social processes involved in the emergence and use of self and social forms of regulation processes (Järvelä *et al.* 2010; Whitebread *et al.* 2010b). Furthermore, the use of observations is viewed suitable for assessing and examining the interplay between the various aspects of students' regulation of their learning processes (Cascallar *et al.*, 2006; Wolters *et al.* 2011).

As Cohen *et al.* (2000) point out, there are two main types of observation in case studies, participant observation and non-participant or direct observation. For the former, the researcher takes an active role within a case study situation and actually participates in the events being observed (Yin, 2003a), whereas the latter refers to the opportunity to observe behaviour and interactions as they occur, without an active participation or involvement of the researcher in the events being studied (Ritchie, 2003). That is, in this type of observation, while the presence of the researcher is accepted by the participants, he/she does not interact with the people or events being observed. In order to be less intrusive to the students and teachers in the process of teaching and learning, for the present study, non-participant, direct observation was deemed as the most appropriate form. The following subsection describes the procedure of the lesson observations carried out for this study.

3.5.1.1 Classroom video observations

The use of video observations presents a number of important advantages in relation to the investigation of teaching and learning processes (Barron, 2007; Derry, 2007). For instance, when compared to just note-taking or audio recording in the classroom, the effective use of video can assist researchers to 'create more closely grounded stories that include the full range of gestural, auditory and contextual subtlety in the thick description of the event' (Goldman, 2007, p. 6). Video recorded data can be

also viewed and analysed multiple times as much as is necessary, as well as allowing for the interpretation and analysis of students' behaviours in context (Whitebread *et al.*, 2009). Moreover, they can be viewed and re-analysed by different researchers with the purpose of checking the veracity of the findings emerging from the initial analysis (Derry *et al.*, 2010). Given these advantages, the use of video recording was selected as the primary data collection tool during the lesson observations.

Table 3.3 – Observation schedule for all the recorded lessons

Students	Date of observations	Types of learning activities observed	Observational data collected and analysed
Group A (Kutay, Leman & Ayse)	Between 23 rd September and 4 th November 2010	Introductory activities (3)	130 min video data
		Small group activities (5)	165 min video data
		Whole class discussions (5)	200 min video data
Group B (Ezgi, Brus & Vural)		Introductory activities (3)	130 min video data
		Small group activities (5)	165 min video data
		Whole class discussions (5)	200 min video data

The observations included in the main study were conducted during 14 (of 17) lessons of the *human body systems* (each lesson approximately 45 minutes duration) as described above over a seven-week period from September to November 2010 (see Table 3.3 for a detail schedule). Observations could not be made during three of these lessons (13 to 15) owing to the absence of Mrs. Celin, as she went abroad to attend a one-week professional development course. During that time, her class was provided with a substitute science teacher.

During the lesson observations, the target student groups were observed and video recorded as they engaged in inquiry learning activities. The main aim was to capture teacher and students' verbal and non-verbal behaviours and social interactions that are indicative of self and social regulation of learning processes. The video data were collected through using two video camcorders, positioned on a tripod so as to record the actions of each of the case student groups during whole class and small group scientific inquiry activities. Bluetooth microphones were used to record teacher and students' discourse and always placed on each case group's desk, while the video camcorders were positioned far away from them in order to lessen any possible disruption to their learning. Also, before the first video recording began, all the students were told that the aim of this research was to record natural classroom practices and thus that they should act as they would normally. The video recordings always started when the teacher started the teaching activity and lasted until the end of the lesson.

In adopting a 'complete observer' role (Creswell, 2003), I usually stayed at the back of the classroom, operating camcorders as well as collecting fieldnotes (e.g., observation date, description of the activities, or any reflection or interpretation of a particular incident) during the lesson observations. Also, I collected a number of relevant documents as additional data sources. At the end of each lesson observation, I asked for permission from both the teacher and the student groups to collect these documents, such as samples of student worksheets and lesson plans, which served to provide additional details regarding the scientific inquiry activities. In fact, their collection made an important contribution to the analysis and interpretation of the observational data, as will become apparent in the chapters 4 to 6.

In spite of its benefits, the presence of video cameras during lesson observations can influence both teachers and students' actual behaviours. In the case of this study, the teacher and students stated that they did not feel distracted by the presence of the video cameras, as they were already familiar with the video recording of their lessons for the teachers' professional development purposes. In addition, in line with other researchers' findings (Barron, 2007; Zhai, 2011), my own observation was that students only noticed the video recording equipment at the beginning of the lessons

and did not pay any attention to it once they were fully engaged with the learning tasks.

While observational data are useful for assessing various aspects of regulation processes in real time and real contexts, as discussed above, they are also limited to examining overt behaviours, and hence cannot offer a complete account of regulation of learning processes, since some of these processes are mental ones internal to the students (Patrick & Middleton, 2002; Perry *et al.* 2002; Wolters *et al.* 2011). Moreover, they do not always provide a clear insight into how students make sense of events and why they act as they do. Therefore, it is recommended that such data to be triangulated by using other types of, such as interviews, so as to increase the validity of findings (Järvelä *et al.*, 2010; Patrick & Middleton, 2002; Perry, 2002). The next section describes the interviews and procedures utilised in the present study.

3.5.2 Interviews

Interviews are one of the main sources of data in the qualitative research approach, by means of which insightful information can be obtained about the phenomenon under study (Bryman, 2008; Creswell, 2003; Legard *et al.*, 2003). That is, through asking questions to elicit a special kind of information, interviewing allows researchers to elicit participants' thoughts, feelings and intentions which observations often fail to bring to the fore most of the time (Merriam, 1999; Patton, 2002). Hence interviews are often used in combination with observations in order to gain 'understanding of how events or behaviours naturally arise as well as reconstructed perspectives on their occurrence' (Ritchie, 2003, p.37).

Interviewing is seen as a valuable approach in the regulation of learning research, as it allows students and teachers to reveal and explain particular events and experiences in their own words and from their own perspectives (Patrick & Middleton, 2002; Perry & Rahim, 2011). Linked with observations, previous studies have successfully utilised different types of interviews to gather qualitative data about various unobservable aspects of students' regulation processes in different contexts (Anderson *et al.*, 2009; Iiskala *et al.*, 2004; Järvenoja & Järvelä, 2005; Perry *et al.*, 2002). In the same way, interviews are used in this thesis to elicit more

detailed information on students' thinking, feelings, perceptions and intentions during their learning process, with the purpose of complementing the analysis of video observation data. The following subsections describe the types and schedules of the interviews used in the current study.

3.5.2.1 Stimulated-recall interviews

Stimulated-recall interview was chosen in this study in order to explore students' self and social forms of metacognitive, motivational and emotional regulation processes in more detail through eliciting their thinking, feelings and intentions during their engagement in scientific inquiry activities. It is a special form of interview that invites participants (students or teachers) to recall and reflect on their actions and feelings while watching video episodes of themselves performing a task or activity (Boekaerts & Corno, 2005).

Two stimulated-recall interview sessions were conducted with each student group half way through and at the end of the data collection period. All these sessions took place in the school library and lasted between 25 to 35 minutes depending on the availability of the student groups, and were audio-recorded for later transcription (see Table 3.4 for a detailed schedule of the stimulated-recall interviews).

In line with the procedures surrounding the use of stimulated-recall interviews (see Anderson *et al.*, 2009a; Nielsen *et al.*, 2009), prior to each round, I first identified and selected several video episodes of the student groups' engagement in inquiry learning activities and later used these as stimuli during the interviews. The identification and selection of episodes from the video data was based on the perspective that the episodes were considered indicative of metacognitive, emotional or motivational regulation processes engaged in by an individual student or the group as a whole. As it is suggested to conduct stimulated-recall interviews as soon as possible after the actual event focused upon (Denley & Bishop 2010; Fox-Turnbull, 2009; Mackey & Gass, 2005; Schepens *et al.*, 2007), all the episodes selected were from the last group activity which the groups had engaged in before the interview session.

Table 3.4 – Stimulated-recall interviews schedule

Interviewees	1st session date & duration	2nd session date & duration	Stimulus used during the interviews
Group A (Kutay, Leman & Ayse)	8 th October 2010 (35minutes)	3 th November (30 minutes)	Video clips & observation transcripts
Group B (Ezgi, Brus & Vural)	7 th October 2010 (35 minutes)	2 nd November (25 minutes)	Video clips & observation transcripts

At the start of the interviewing, the students were provided with an explanation and clarification about the purpose and procedure of the stimulated-recall interview, as it was the first time they participated in this type of activity. Next, they were asked to watch the video episodes of themselves and recall and reflect on their own learning processes and group interactions during these incidents. Open-ended questions were mostly used during the interviews, which were aimed at prompting the students to describe and explain what they were doing, feeling or thinking at the points which were critical in the episodes they watched. I asked questions, such as ‘OK, let’s talk about what’s happening here?’, ‘What were you thinking at this point?’, ‘How did you feel at that moment?’, ‘You seem a little bit upset here, what was your actual feeling? Why?’.

The students were also able to look at the transcription of the episodes if they needed to and in some cases, the episodes were played more than once in order to enhance the effect of the stimuli for the students. Also, conducting the stimulated-recall in the group increased the validity of the procedure, as the presence of other group members served as another type of stimuli that enabled collective discussion and reflection of all students on the incidents shown during the interview sessions.

Overall, the use of the video episodes as stimuli facilitated the students' reflection on the metacognitive, emotional and motivational aspects of their learning processes.

As Fontana and Frey (2005) point out, before the interviewing begins, it is crucial to create a friendly and familiar atmosphere so that a mutual trust can be established between the researcher and interviewees. In the case of this study, the lesson observations carried out before the stimulated-recall interviews presented an opportunity for me to build a rapport with the students, which helped in creating a comfortable and pleasant atmosphere during all the interviews.

3.5.2.2 Semi-structured interviews

The semi-structured interview approach was chosen in this study in order to explore the students' attitudes, beliefs and perceptions about the scientific inquiry activities they engaged in during the lesson observations. Semi-structured interviewing is seen advantageous, as it offers the researcher 'considerable flexibility over the range and order of questions within a loosely defined framework' (Wellington, 2001, p. 74). Moreover, because it is sensitive and flexible to the social context in which the data are produced, semi-structured interviewing enables responses to be fully probed and explored, and the interviewer to be responsive to the relevant issues emerging during the interview (Legard *et al.*, 2003). That is, this approach allows the researchers 'to take a grounded, inductive approach to understanding students' thoughts and behaviours, rather than only imposing their theoretical perspective or pre-established categories on what students say' (Patrick & Middleton, 2002, p.28).

In this study, semi-structured interviews were conducted with the students as a group only once following the completion of the second stimulated-recall interview session. These interviews took place in the school library, lasted about 25 minutes and were audio-recorded for later transcription. I developed and utilised an interview protocol which comprised a set of questions. These questions were aimed at gaining insight into the students' attitudes, beliefs and perceptions concerning science learning in general (e.g., 'Can you explain why you are learning these scientific topics?', 'Do you think that learning about science is meaningful and useful for you?', 'What is the most interesting thing to you during science lessons? Why?') and the small group collaborative activities they engaged in (e.g., 'Do you think that the group work is

important for your learning? Why?', 'Why do you think that you are important for your group's functioning?'). Appendix D provides the whole interview protocol.

While I also wanted to conduct both semi-structured and stimulated-recall interviews with the teacher, this was not possible due to the lack of her available time. Hence, only a few informal conversations were conducted with her throughout the data collection period. This included asking questions about her reflections on her teaching practice and the case students during the lessons. In addition, her ideas and recommendations about the research procedures were sought in order to improve the data collection process. These interactions were audio recorded where possible or handwritten either at the time or soon after the event.

3.6 Data analysis

For this current study, different types of data from the various collection tools were gathered as described above. Subsequently, a range of techniques were used for the analysis of the observational (video) data, field notes, documents as well as the stimulated-recall and semi-structured interviews. This section discusses these techniques utilised to probe students' regulation of learning processes and hence be able to address the research questions of this thesis.

3.6.1 Coding schemes for the analysis of video and stimulated-recall interview data

In order to tackle the first research question, two coding schemes within a multi-step analysis design were used to capture the evidence of self-, co-, and shared regulation of learning processes that emerged from the video data and stimulated-recall interviews.

For the first analysis step, a coding scheme was developed in order to identify and analyse incidents that indicated evidence of students' regulation of their learning processes. The initial coding scheme was drawn up based on several theoretical models of SRL and previous research literature. In line with the objectives of this current study, it included two main categories, namely metacognitive and motivational and emotional regulation, and several sub-categories within each main category (e.g., planning, monitoring, control & evaluation processes). Primarily,

these initial coding categories were derived from Pintrich's (2004) conceptual framework of SRL and Zimmerman's (2000) social cognitive model of SRL (see Appendix A for more details about these models). They were also based on the coding scheme developed by Winters and Azevedo (2005) for investigating students' regulation of their learning in a collaborative computer-based scientific inquiry context, as well as that of Whitebread *et al.* (2009) which was used to assess pre-school children's regulation of their learning processes.

During this step, the students and teacher's verbal discourses were transcribed verbatim and their non-verbal actions (e.g., eye contact, body language, hand speed, facial expression, and tone of voice) were noted in italic font within the parenthesis. An utterance(s) and /or nonverbal action(s) in the transcripts represented the coding units for this step. An utterance was defined as any verbal statement with a particular function and meaning (akin to DeWitt, & Hohenstein 2010) and similarly, nonverbal actions referred to any behaviour which had a specific function and meaning. In some cases, when one utterance or nonverbal action served two functions, it was assigned two different codes. On the other hand, if several utterances and/or nonverbal actions served the same function, only a single code was applied. Regarding the transcripts, utterances and nonverbal actions were represented in terms of turns (3963 turns in total). A turn was defined as the utterance and/or nonverbal action of a person bounded by another person's utterance and/or nonverbal action. Here, a turn could include only a single utterance and/or nonverbal action or several utterances and/or nonverbal actions. The transcriptions were double checked in order to ensure their accuracy.

In relation to their function and meaning, all the utterances and nonverbal actions were comprehensively analysed through an iterative process in order to see if they constituted evidence of belonging to any a priori categories of the initial scheme or could be constituted into a new specific code. Through reading the transcriptions and viewing the video recordings in these iterative cycles, I identified incidents which indicated evidence for metacognitive, motivational and emotional regulation processes. During this process, all initial coding categories were tested and refined, whereby some of the initial definitions of subcategories were adjusted in terms of operationalisation, and some of the initial subcategories were removed from the

coding scheme because there was no clear evidence for them within the analysis of the data set. The utilisation of this approach offered an opportunity to see what was actually in the data, rather than simply imposing the existing categorisations. This process was repeated a number of times until obtaining the final version of the coding scheme which was in line with the theory as well as grounded in the data.

In the final version of this coding scheme, metacognitive regulation included three subcategories, namely planning, monitoring and evaluation. Motivational and emotional regulation included two subcategories, namely monitoring and control processes. Table 3.5 illustrates an example analysis of the video data through this coding scheme. In the extract below, Ayse's utterance and nonverbal action in turn 4 were coded as a metacognitive monitoring process since their function was to make an assessment of Leman's understanding of the subject. Similarly, Ayse's utterance in turn 6 and Kutay's utterances in turn 12 were coded as a metacognitive monitoring process since they were doing an assessment of their own understanding. In relation to turn 11, Leman's utterances and nonverbal action were also coded as a monitoring process as she was seeking an agreement from her partner about a conceptual idea which led her group to monitor their mutual understanding.

Table 3.5 – An example of the analysis of video data through the coding scheme

1	L: Now, first of all, the child sees the ball which is coming to him (<i>looking at her partners</i>).	
2	Ay: This becomes a reflex.	
3	L: A message is sent to the brain instantly.	
4	Ay: Umm, the message doesn't actually go to the brain (<i>looking at her notes</i>). [Metacognitive monitoring – Assessment of understanding or learning (AUL)]	
5	L: Isn't the brain functioning? (<i>glancing at Ayse</i>). – Questioning for understanding (QfU)	[Metacognitive monitoring]
6	Ay: I am not sure. I haven't listened very well. I have only focused on the video clip. [Metacognitive monitoring – AUL]	

-
- 7 K: I have listened. Now, look, actually when he sees for the ball first time, this goes to the brain.
- 8 L: Look, when he sees it (*glancing at Ayse*).
- 9 Ay: OK, this isn't a reflex. [Metacognitive monitoring – Realising a mistake or misjudgement (SC)]
- 10 K: From brain to cerebellum, from cerebellum to spinal bulb and spinal cord, then it follows all of the neural ways. That means it starts from here (*pointing his brain*) and spreads throughout the body. It comes from the brain, because the eyes are connected to the brain (*stands up and explains by pointing to his body*).
- 11 L: Yes, the ball comes and the eyes send a stimulus to the brain. The brain responds to the stimulus by means of the peripheral nervous system or in other words with our nerves, OK? (*looking at her partners*) [Metacognitive monitoring – Seeking support or agreement from a partner(s) about a conceptual idea (SA)]
- 12 K: Um, but there is a problem like this. Since the child's action of flying to the ball is a kind of acquired reflex, this is not very clear (*glancing at Ayse*).
[Metacognitive monitoring – AUL]
-

All the evidence of the students' regulation of their learning processes during scientific inquiry activities was coded by using the final version of the coding scheme which is illustrated in Table 3.6. This coding scheme includes operational definitions of each of the regulatory category as well as descriptions of regulatory processes and examples from the video data. The categories were not mutually exclusive and exhaustive (more than one code could be associated with a particular event, and there was not a code for every event in the video data) (see Bakeman & Gottman, 1997). All the categories involved in this coding scheme were discussed with my supervisors with the purpose of confirming the veracity of this categorisation.

Table 3.6 – Coding scheme for the students’ regulation of learning processes

Categories & Sub-categories	Description of Behaviour	Examples
Metacognitive regulation		
<i>Planning</i> Any utterance, nonverbal action, interpretations and/or appraisals concerning the understanding of task goals or the procedural aspects of the task	- Setting goals or subgoals in relation to the task (GS) - Clarifying and coordinating conditions about the task (CC) - Asking or deciding on how to proceed with the task (PT) - Assigning individual roles or negotiates responsibilities concerning the task (AN) - Prior knowledge activation (PA)	➤ ‘L: Now, we will write about the journey of these nutrients in our body and explain in which sections of the digestive system they are digested chemically as well as physically. So, should we write a story for this activity or explain everything separately (<i>looking at her partners</i>)?’ (PT) ➤ ‘Ay: Let’s look at this diagram too. L: OK. K: Can I, can I explain this one? Ay: Yes, go ahead.’ (AN) ➤ ‘E: Should we answer the next question now? (<i>glances at the partners</i>) V: This is a very long question. E: Um... V: It is asking us to explain which parts of the nervous system

		function when the child pulls his hand away (<i>points at the activity sheet</i>). E: Such as stimulus, sensory neurons. B: Yeah (<i>nodding</i>), this one is similar to third question.’ (CAC)
<i>Monitoring</i> Any utterance, nonverbal action, interpretations and/or appraisals associated with the ongoing assessment of understanding of the task content or actual performance of the task	- Making an assessment or judgment of own or other’s or their mutual understanding or learning (AUL) - Monitoring actual progress to assess if any learning goal has been achieved (MAP) - Asking a question in order to check, assess or improve the level of understanding or learning (QfU) - Realising a mistake or misjudgement made by him/herself or as a group (SC) - Seeking support or agreement from a partner(s) about a conceptual idea (SA)	➤ ‘Ay: I still don’t understand how this [video] is related to this subject.’ (AUL) ➤ ‘E: Now, we have answered only one question. We have explained the duty of the pituitary gland and so on. V: OK, let’s look at the next question’ (MAP) ➤ ‘B: But, I am not sure if it is going to the brain’ (AUL) ➤ ‘B: Are you sure that this [explanation] is true (<i>speaks with an uncertain voice tone</i>)?’ (QfU) ➤ ‘E: Teacher, can I ask you something? For example, goalkeepers are trained to jump towards the speedy balls. But after sometimes, this [their action] is becoming a reflex, isn’t it?’ (QfU) ➤ ‘K: Sorry, I put this arrow into a wrong place.’ (SC)
<i>Evaluation</i>	- Reviewing group’s overall learning	➤ ‘L: Now, let’s talk from the beginning (<i>glances at her partners</i>).

Any utterance, nonverbal action, interpretations and/or appraisals related to reviewing overall learning process and outcomes, usually toward the end of task completion	process or progress (RLP)	For the first question, we suggested three types of events, for which we can give different examples when considering our daily lives' (RLP)
Motivational and emotional regulation		
<i>Monitoring</i> Any utterance, nonverbal action, interpretations and/or appraisals related to the assessment of current motivational and emotional states during the task	- Expressing awareness of his/her negative emotional experience, such as annoyance, embarrassment, boredom, disappointment (EM) - Expressing awareness of motivational experiences, such as lack of interest, wonder, difficulty, distraction in relation the task (MM)	➤ 'B: Actually (<i>looking at the partners</i>), I have had a lot of questions at the beginning, but I have learnt almost everything. Now, I don't really wonder about anything.' (Expression of lack of interest - MM) ➤ 'V: Oof, Brus! We cannot read the question because of you (<i>looks with a frowning face</i>)' (Expression of boredom - EM) ➤ 'B: Ok, you [his group partners] now exclude me, after all the discussion we have had (<i>looks with a sad and angry face</i>)' (Expression of disappointment - EM) ➤ 'K: Ok Leman, uff! You are always the right one, anyway (<i>raises his shoulders while looking at his notebook and speaking in a low tone of voice</i>) (<i>glances at Leman</i>)' (Expression of annoyance – EM)

<i>Control</i> Any utterance, nonverbal action, interpretations and/or appraisals associated with the regulation and control of emotional and motivational experiences during the task	- Encouraging him/herself or others - Controlling attention - Praising or giving compliment - Attention Shifting - Interest enhancement - Remaining optimistic - Considering mistakes as a part of learning process - Promoting a sense of tolerance and respect within the group	➤ ‘E: But let’s think together, let’s force our imagination. And the most interesting questions always come from Vural, let’s first listen to him. He may stimulate our mind too.’ (Encouraging her group partners) ➤ ‘T: Yes, wonderful, this is the most noticeable event in this activity’ (Praising) ➤ ‘B: A really nice explanation (speaks to Ezgi)’ (Giving compliment) ➤ ‘V: Like blood incompatibility. T: It isn’t exactly like this. B: You have gone so far away (<i>laughs and makes fun of V</i>). T: It has a system that... V: Yes, I have (<i>smiles and speaks with low tone of voice without looking at B</i>)’ (Considering mistakes as a part of learning) ➤ ‘L: Kutay, can you write please (<i>looks at Kutay</i>)? K: You haven’t written yet (<i>points at Leman’s notebook</i>). L: We are writing now.’ (Controlling attention)

For the second step analysis, another coding scheme was utilised in order to identify and analyse episodes indicating a self, co or shared focus of the regulation processes in the coded data through adopting the operational definitions used by Liskala *et al.* (2004; 2011) and Whitebread *et al.* (2007, 2009). That is, through reading the transcripts and viewing the video recordings, I carefully examined the function and focus of each regulatory utterance and nonverbal action within the sequence of an interaction. With the aim of informing and supporting this analysis, I also utilised the aforementioned field notes, student worksheets and lesson plans, in particular, to characterise the social context in which students' learning took place. In accordance with previous research, the unit of analysis for this analysis step was at the episodic level, since co- and shared regulation of learning always comprise at least two turns or more (Liskala et al. 2011; Volet et al, 2009b). For this coding process,

- An episode was considered as *self-regulation* when a student regulated their own learning process, without any clear intention of influencing other students' cognition, motivation or emotion. This form of regulation was always specific to one student and located only in this student's turn. Such an episode usually comprised a single turn and in some instances a set of turns together.

- *Co-regulation* represented episodes in which the regulation processes were directed to influence others' cognition, motivation or emotion in order to assist and guide his/ her learning. This interpersonal interaction was always in an asymmetrical form in which an unbalanced contribution and low level reciprocity in the dialogue was visible among the students (and teacher). Such an episode usually included a student(s) or teacher regulating the learning process of another student or a group of students who needed some assistance with some aspect of the learning task or who was/were not performing well with the learning task, or one student or a group of students requesting or prompting another student(s) or the teacher to regulate his/her/their own learning processes. This type of episode usually started with a student or the teacher's utterance or nonverbal action which appeared to be the initiating point for co-regulation and finished with another turn that indicated its end, that is, the end of the interaction.

- An episode was classified as *shared regulation* when multiple students regulated their collective activity in order to achieve a shared goal. In this type of episode, at least two group members' balanced regulatory involvement was essential, as they had to regulate jointly the group's cognitive, motivational or emotional processes towards a shared goal with a high level of reciprocity. This type of episode always began with a turn which appeared to be the starting point of group's collective regulation and finished with another turn in which the joint regulation ended. During such an episode, students' reciprocal interactions were expected to influence the group's direction of the learning activity. All the turns between the beginning and end of episodes were deemed to be part of the episode irrespective of their reciprocal or regulatory character.

In order to enhance the reliability of the data analysis for the first two steps, another doctoral student was invited to code independently 15% of the transcribed video data by using the two coding schemes explained above. Since these coding schemes were not exhaustive, this process was carried out in two phases in line with the recommendation of Bakeman and Gottman (1997) and procedure utilised by Whitebread *et al.* (2009). During the first phase, agreement on unitising was sought (i.e. agreement about which utterance and/or nonverbal action should constitute a unit of coding in the selected data). The second phase involved the calculation of absolute levels of agreement (i.e. agreement about which categories of the coding schemes should be ascribed to the agreed units of coding). Regarding the level of unitising, we reached 63% agreement, a value which is considered acceptable for this type of study involving categories that include higher levels of inference (Bakeman & Gottman, 1997). For the application of the first and second coding scheme, the percentage of absolute agreement was 90% (Cohen's $K = 0.86$) and 89% (Cohen's $K = 0.74$) respectively, which represents substantial levels of agreement for both coding schemes (Landis & Koch, 1977; Miles & Huberman, 1994), and any remaining disagreements were resolved through discussion. The process of inter-coder agreement was important as it was helpful in enhancing my own reflectivity and awareness of the coding and analysis processes as well as ensuring my coding system was transparent, coherent and understandable for other researchers (Joffe & Yardley, 2004).

The third step involved analysis of the stimulated-recall interview data conducted with groups A and B. Firstly, the interviews were transcribed verbatim, and students' responses (approximately 275 turns) were analysed and compared with the analysis of the video episodes (14 clips in total) shown during the stimulated-recall interviews. During this process, the students' reflections and interpretations which were indicative of their regulation processes were identified and coded through utilising the categories of both the coding schemes used for the previous analysis steps. This analysis provided an invaluable additional insight into elucidating and understanding students' self and social regulation of their learning processes by revealing how, why and what the students were thinking or feeling while engaging in scientific inquiry activities. It also supported and complemented the analysis of video data through allowing for an understanding of the observations from the students' perspectives (see Table 3.7 for an example analysis).

Table 3.7– An example of the analysis of the stimulated-recall interview data

Stimulated-recall interview transcript	
31	Interviewer (I): OK, we will watch another episode now.
32	All: (<i>watching</i>)
33	Ezgi (E): He is such a difficult child (<i>makes a comment while watching the episode</i>)...
34	Brus (B): Now, here we were talking. Then, a question came to my mind. I thought what would happen if the pituitary gland didn't secrete the hormone or if the kidneys didn't send the signal.
35	I: Yes.
36	B: ~~When Vural responded negatively, my nerves couldn't resist and I burst into anger there.~~ [Motivational and Emotional Monitoring – Self]
37	E: Actually, we were writing our answer, and Brus said 'one minute!' There were a lot of questions to be answered and our time was so limited.
38	Vural (V): Yes, he was asking an extra question.
39	I: OK, let's continue now.
40	All: (<i>watching</i>)
41	I: What's happening here?

-
- 42 V: He said that the urine bladder is alive.
- 43 E: But it was correct.
- 44 V: Yes, I accept that it consists of cells.
- 45 I: Brus.
- 46 B: When I am pretty curious about something, I usually ask questions. I suppose, in this case, my friends felt they had to finish their task first, that's why they got angry with me. So, we jumped into this argument. [Motivational and Emotional Monitoring – Shared]
- 47 All: (*watching the episode*)
- 48 E: He was sad here and I said, please... [Motivational and Emotional Monitoring – Shared]
- 49 I: Yes, what did you do?
- 50 E: Brus was assuming a pose and sulked with us. So I tried to make him join us again. [Motivational and Emotional Control – Shared]
- 51 V: Plus, we learnt that his idea was correct. Basically, the urine bladder is alive since it consists of cells.
- 52 E: Actually, Brus made really good contributions, and mentioned really great ideas.
- 53 B: But they didn't really take them into consideration.
- 54 I: OK, let's look at another part now.
-

For the last step, in order to identify and explore if and how the different types and forms of regulation processes are related to one another, some of the lengthy sequences of regulation episodes were scrutinised and analysed qualitatively. For this purpose, time flow charts were utilised which helped identifying and describing the patterns of interactions regarding the students' self and social forms of metacognitive, motivational and emotional regulation processes.

3.6.2 Times-series analysis

In order to address the second research question, time-series analysis (Yin, 2003) was conducted to explore how the students' regulation of their learning processes changed over time across different types of learning activities as well as across the student groups. For this purpose, the occurrences of the regulation episodes identified in each category of the coding schemes were calculated and analysed quantitatively.

Since the scientific inquiry unit observed in this study involved three main topics, each made up of different types of activities with different durations per session, it was considered that the frequencies of episodes per every ten minutes would be a more suitable and adequate way to present the results rather than the overall frequencies (Bakeman, 2000). Hence the statistical data is presented in terms of rates, which denote the frequency of episodes occurring in each ten minutes of the learning activities (see Appendix B for the duration of each activity). As will be explained in the next subsection, this analysis was combined with the thematic analysis of the semi-structured interviews with the students.

3.6.3 Thematic analysis

In addressing the third research question, thematic analysis (Braun & Clarke, 2006; Ritchie *et al.*, 2003b) was conducted to explore when and how the social forms of metacognitive regulation episodes, identified within the analysis of video and stimulated-recall interview data, were initiated by the students or the teacher during scientific inquiry activities. In this analysis, in line with the stages of thematic analysis suggested by Braun and Clarke (2006), I read through the transcripts and viewed the video recordings in order to familiarise myself with the data set and gain a sense of it as a whole. Next, I identified and described the utterance(s) and/or nonverbal action(s) which appeared to be the initiating moment of each social form of metacognitive regulation episode. This process involved creating and noting down the initial codes inductively for the episodes in the data set. After this initial analysis, I looked again at these initial codes, and started to sort them into the potential themes. This was followed by reviewing and refining all the themes, whereby they were checked in relation to all the coded episodes as well as the entire data set. Finally, the last stage involved creating clear descriptions and names for each of these themes. All the themes that emerged from the data were discussed with my supervisors and another researcher with the purpose of confirming the veracity of the analysis.

Thematic analysis was also used for the analysis of the semi-structured interviews conducted with the target students with the aim of exploring their attitudes, beliefs and perceptions about the scientific inquiry activities they engaged in. Using a

similar analysis procedure to that recommended by Braun and Clarke (2006), firstly, I transcribed the interviews verbatim and read through the transcripts carefully to gain a general idea of their content. Next, I created and noted down initial codes inductively for the student's responses, and sorted these codes into the potential themes which were later reviewed and refined iteratively (see Table 3.6 for an analysis example). The final themes that emerged from the interview data were as follows: 'personal achievement goal', 'friendship', 'leadership', 'roles within the group', 'ideas about the role of group work' and 'ideas about the role of the teacher'. All these themes were used to create a profile for each student and group, which complemented the interpretation and analysis of the observational data about the changes in students' regulation of their learning processes over time.

Table 3.8 – An example of the analysis of the semi-structured interview data

	Interview transcript	Initial coding	Themes
15	Interviewer (I): As we know, at the moment, you are studying the human body system unit. What do you think about the activities being carried out currently? Are they meaningful or helpful for your learning?		
16	Leman (L): I think they are really helpful for us. Umm...		
17	I: Can you give any example?		
18	L: In the first lessons, <u>I really enjoy the group work and I was also pleased with my group. We worked together, so it was really nice in the beginning of seventh grade, with the excitement of the new academic year.</u>	<u>having enjoyable learning</u>	
19	I: You (Ayse)?		Ideas about the role of
20	Ayşe (Ay): I agree with Leman, <u>I like the</u>		

	<u>activities which we do as a group.</u>		group work
21	I: Yeah, why do you like them?		
22	Ay: <u>Because everyone was sharing their thoughts as a group.</u>	<u>Sharing viewpoints with each other</u>	
23	I: OK, what do you think, why are you learning these science topics?		
24	Ay: I don't know, <u>the topics are so interesting, and I think it is important for us to have some knowledge about them.</u>	<u>Learning science is interesting and necessary</u>	
25	I: OK, what do you think, Kutay?		
26	Kutay (K): <u>Science is a very fun lesson, since we explore our body structures. It is usually very interesting. I mean I like it.</u>	<u>Learning science is fun and interesting</u>	
27	I: Alright, which system do you most like?		Personal achievement goal
28	K: Well, I suppose, <u>the nervous system was fascinating for me, but as well as it was the most difficult one.</u>		
29	L: <u>It is also interesting for me, because I have been always wondering about the brain since I was a little kid.</u>	<u>Learning science is interesting</u>	

In addition, for both thematic analyses, the transcripts of the data sets were uploaded to the Nvivo8 qualitative data analysis software (produced by QSR International) which helped in managing, coding and making sense of the data in a systematic way.

3.7 Trustworthiness of the research

In qualitative research, a number of specific processes are available for ensuring trustworthiness, which is described as an indicator of the veracity of a study. For instance, as Lincoln and Guba (1985) suggest, trustworthiness in a qualitative research can be 'established by the use of techniques that provide truth value through

credibility, applicability through transferability, consistency through dependability and neutrality through conformability' (cited in Erlandson *et al.*, 1993, p. 132). Similarly, Holloway and Wheeler (2002) recommend several ways to ensure trustworthiness, including triangulation, member validation, audit trail, multiple coding and reflexivity. For the current thesis, a number of procedures for helping establish trustworthiness of the study were utilised, and these are presented in the following subsections.

3.7.1 Credibility

Credibility is concerned with the confidence in the truth of the data and interpretations of them (Lincoln & Guba, 1985; Polit & Beck, 2008). In this study, the techniques utilised to ensure the credibility of the findings and interpretations included prolonged engagement and triangulation.

- *Prolonged engagement*

Spending sufficient time in the context helps the researcher develop an in-depth understanding of the phenomenon under study, which ultimately enhances the validity of the research by making the findings and interpretations more credible and accurate (Creswell, 2009; Lincoln & Guba, 1985). In this study, I spent more than two months in the field and I was present in the school almost four times a week, not just for the data collection but also to speak to the teachers and students, and to become familiar with the specific school environment. This allowed me to build a trusting relationship and foster a rapport with these people, as well as understand the social and emotional climate of the case classroom.

- *Triangulation*

Triangulation refers to 'the use of different methods and sources to check the integrity of, or extend, inferences drawn from the data' (Ritchie, 2003, p.46). According to Stake (2006), it is a process of repetitious data gathering and critical review of what is being said or interpreted. Different types of triangulation are described in the literature, such as the use of multiple and different methods, sources, theories, and researchers (Holloway & Wheeler, 2002; Patton, 2002). In the case of this study, in order to enhance the credibility and validity of the findings and their

interpretations, multiple techniques were utilised to collect the data (observation, interviews and documents) and also to analyse it (thematic analysis, time-series analysis, coding schemes etc.). This provided an opportunity to see if the interpretations of data clearly reflected the participants' perspectives and actions. Also, different researchers took part in the coding and analysis of the video data with regard to the measurement of students' regulation, which served to increase the validity of the analysis process as well as the reliability of the research.

3.7.2 Transferability

Transferability, known also as external validity, concerns the extent to which the findings of the research can be transferred to or have applicability in other contexts (Lincoln & Guba, 1985). Unlike quantitative research in which the transferability can be ensured by the similarity of the research sample to the general population, in naturalistic, qualitative studies, much of the responsibility of evaluating the applicability of findings to new situations lies with the reader of the research. With respect to this, as Lincoln and Guba (1985) note, the responsibility of a qualitative researcher is to provide 'sufficient descriptive data to make such similarity judgements possible' (p.298). Likewise, Creswell (2009) suggests that by providing thick description, it may be possible to 'transport readers to the settings and give the discussion an element of shared experience' (p.191). Following these recommendations, in order to increase the transferability of this current study, I collected detailed descriptive data and presented illustrative descriptions and quotes during the data analysis. In particular, the field notes and observational video data were helpful in producing thick, rich descriptions of the context of the research, participants and phenomena under scrutiny.

3.7.3 Dependability

Dependability is described as an assessment of the quality of the integrated processes of data collection, data analysis, and theory generation (Lincoln & Guba, 1985). It also refers to the consistency, predictability, stability or accuracy of a study's findings over time and for different conditions (Erlandson *et al.*, 1993). For this study, it is difficult to ensure the dependability criterion, given the changing nature of the phenomena under study. That is, as with any qualitative research, even carrying

out this study through utilising the same methodological design with the same participants could not guarantee obtaining the same results, since the participants' perspectives, behaviours and interactions are likely to change under different circumstances.

To address this issue, detailed documentation of all the research processes and decisions was made, so as to enable a future researcher to replicate this study, if not necessarily obtaining identical results. Moreover, the regular meetings with my supervisors and frequent discussions with a competent peer concerning the data collection and analysis processes helped in establishing an 'audit trail', which 'made it possible for an external check to be conducted on the processes by which the study was conducted' (Erlandson *et al.*, 1993, p. 34).

3.7.4 Confirmability

Confirmability refers to the degree which the study's findings are determined and supported by the focus of the inquiry and not by the biases of the researcher (Lincoln & Guba, 1985). It can be described as the qualitative researcher's concern with the neutrality or objectivity of the inquiry (Shenton, 2004). In this thesis, several strategies were utilised to ensure confirmability. Firstly, I provided detailed information concerning the data collection, coding and analysis processes with the purpose of ensuring that the research process was adequately transparent for the readers. Secondly, inter-coder agreement was established with a PhD student, who was not involved any part of this study, in order to ascertain that the coding and analysis processes were being performed reliably. Thirdly, I presented some of the preliminary findings of my study at the British Education Research Association (BERA) Annual Conference 2011, which resulted in constructive feedback and comments being received with regard to the research process from experienced and well-informed academics.

Furthermore, because the researcher is the primary instrument in both data collection and interpretation, it is suggested that he/she must identify and highlight his/her own biases and perspectives, and their possible influence on the inquiry (Creswell, 2009; Guillemin & Gullam, 2004; Patton, 2002). Regarding this, for this study, in order to make certain that the interpretations and findings correctly reflected the students'

inquiry learning experiences, I put aside my preconceived notions about the regulation of learning theory and remained open-minded, paying great attention to not letting any of my personal beliefs and assumptions have an impact on any part of the research process.

3.8 Ethical considerations

The current study followed the BERA Ethical Guidelines (2004) and received approval from King's College London Research Ethics Committee (REP (EM)/09/10-35) and the Turkish Ministry of National Education. A number of ethical issues have been addressed in this research, such as obtaining informed consent, guaranteeing confidentiality and anonymity, and protecting participants from risk or harm.

- *Voluntary informed consent*

In order to obtain informed consent, all the students and the teacher were provided with a full explanation of the purpose of and procedures pertaining to the research in written format and verbally (such as the nature of his/her involvement in the research, duration of the research, interview schedule, and the data collection equipment). They were then invited to sign a consent form for their participation in the study (see Appendix E for the information sheets and consent forms). Moreover, the students were required to obtain the signed consent of a parent or legal guardian in order to be audio and video recorded in the lesson observations and audio recorded during the interviews. All the participants were informed about the importance and benefits of their participation in this research. They were also told that their participation was voluntary and they had the right to withdraw from it at any stage, without giving any reason.

- *Responsibility to the participants*

Researcher responsibility to the participants includes ethical concerns, such as ensuring confidentiality and anonymity, avoidance of any risk or harm and providing feedback on the research results. In this study, the anonymity of the students and the teacher was ensured through using pseudonymous for all the names as well as changing any other identifying details (such as school name, location) beyond

recognition. In addition, all the audio and video files and transcripts were labelled in a way which ensured anonymity, and were stored separately from any identifying information.

Because ensuring anonymity is usually difficult in video research (Derry *et al.*, 2010), the confidentiality of the participants was protected through limited access to the video data and any personal information. As highlighted in detail in the information sheets, only my supervisors and I had full access to the video data, and only the students participating in the stimulated-recall interviews were able to view some of the video episodes of their science lessons. Further in relation to privacy, great care was taken when selecting the video episodes to ensure that none of them had any capacity to cause harm to the participants in any way.

In the interviews, some of the students disclosed their feelings and thoughts about their science teacher and lessons that they did not want their teacher or peers to know about. With regard to this, as stated in the information sheet, I maintained the confidentiality of the interview data, as well as taking great care not to share any information with others which could be considered as harmful for the students or the teacher. Moreover, to make students feel comfortable, they were reminded that they would not be assessed on the answers they gave during the interviews in any way, as well as reassuring them that they could refuse to answer or comment on any of the interview questions, without giving any reason.

To ensure equal opportunities for all the students in the class, the teacher was also requested to avoid giving any special interest or attention to any case student during the lessons. In addition, as requested by the science teacher, brief interviews were conducted with the other student groups with the purpose of not letting them feel worthless compared to the case groups. Furthermore, it was considered appropriate not to let any of the students know about the rationale of the selection of the case groups. Finally, the participating teacher and school management were provided feedback on the preliminary research results so as to demonstrate recognition and appreciation for their involvement in this research.

3.9 Chapter Summary

In this chapter, the overall methodology of this thesis, which was informed by the interpretive qualitative research approach, has been explained and justified. Initially, the theoretical and methodological foundations of qualitative research were discussed. Next, given the aims and objectives of this study, why a qualitative case study research method best suited these was explained and justified. Subsequently, detailed descriptions of the participants and the instructional context of this study were provided and this was followed by a comprehensive presentation of the data collection and analysis processes. Finally, there was discussion about the trustworthiness of this study and the issues of ethics that needed to be addressed. The methodological contributions and the limitations of the research will be discussed in the final chapter of this thesis. In the next three chapters, the research findings will be presented based on the analysis of the collected data.

Chapter 4 – Student Regulation of Learning During Scientific Inquiry Activities

4.1 Introduction

In addressing the first research question of this thesis, this chapter aims to examine the types of regulation of learning processes upper primary students used during the scientific inquiry learning activities. Moreover, it explores if and how different types of self and social regulation processes are interrelated with one another.

As explained in Chapter 3, the measurement of students' regulation of their learning processes was carried out based mainly on two sets of evidence: video recordings of their behaviours while engaging in scientific inquiry activities and the group stimulated-recall interviews performed half way through and at the end of the data collection period. As explained in detail in the methodology chapter (see Section 3.6.1), the analysis of regulation processes was carried out through utilising two different coding schemes within a multi-step analysis design. In this analysis, firstly, the data set was analysed and coded by using the first coding scheme that included two main categories, namely metacognitive regulation (planning, monitoring and evaluation phases) and emotional and motivational regulation processes (monitoring and control phases). The second coding scheme was used to identify and analyse episodes indicative of self, co or shared focus of the regulation process in the coded data. For each of the coding schemes, the types of evidence taken into consideration involved teacher and students' verbal behaviour, social interactions, facial expressions, vocalisation, and use of specific body language gestures when carrying out the scientific inquiry activities, as well as the latter's interpretations and appraisals explicated during the stimulated-recall interview sessions.

During this analysis, the interactions which occurred before and after each regulation episode were also taken into account when interpreting the function and meaning of the utterances and nonverbal actions of the participants, as suggested by Scott *et al.* (2006). Furthermore, each episode was analysed and interpreted in relation to the social context, in which it emerged, and the objectives of the scientific inquiry

activity the students were engaged in. The next sections illustrate evidence of each type of regulation process engaged in by the upper primary students while learning about the topic of *human body systems* during scientific inquiry activities. In order to present this analysis in detail, example episodes of regulation processes and excerpts from stimulated-recall interview transcripts are presented along with my interpretations. All the illustrative examples selected are consistent with the rest of the data set.

In addition to this qualitative analysis, occurrence of each category of the regulation processes across the types of scientific inquiry activities is also described quantitatively in this chapter. As explained in Section 3.6.2, this data is presented in terms of the rates of frequency of episodes occurring during each ten minutes of the learning activities. All the regulation episodes were classified if they occurred in an introductory activity, small group activity or whole class discussion, as well as if they were occurring only among the students or between them and the teacher. Lastly, in order to elicit some of the possible relationships between the types of the regulation processes, time flow charts of some lengthy sequences of regulation episodes were chosen and analysed qualitatively. This analysis involved scrutinising and identifying if and how the occurrence of self and social forms of metacognitive and motivational and emotional regulation processes influence and interact with one another.

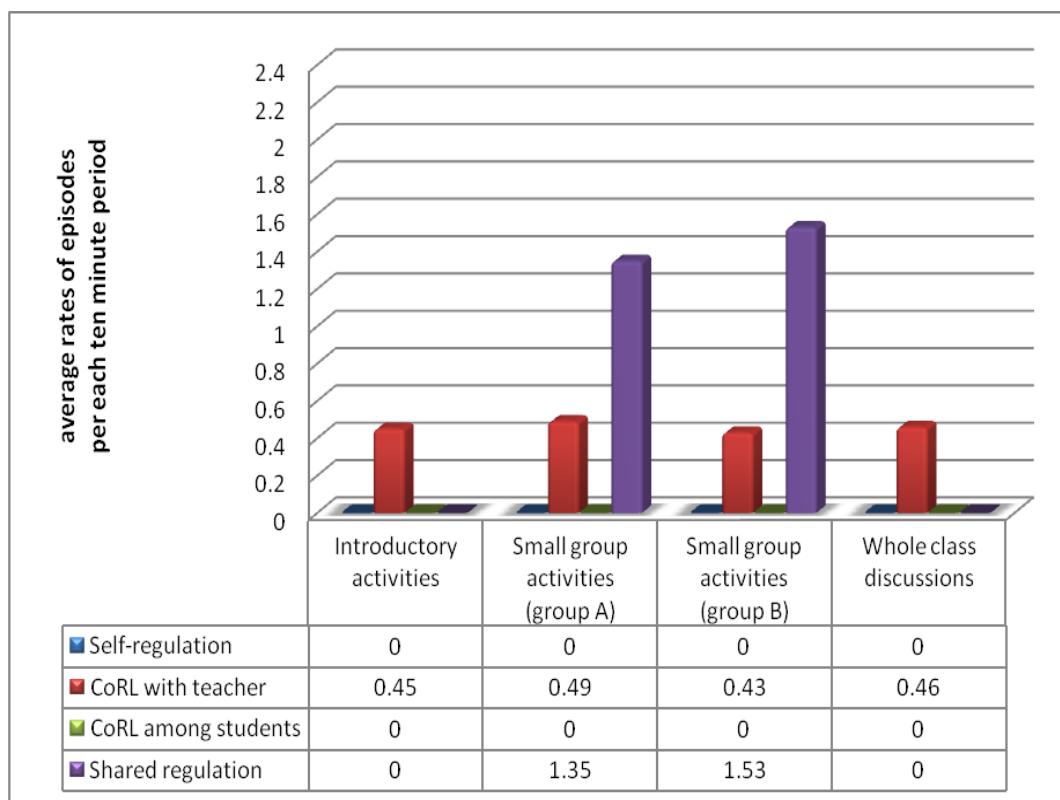
4.2 Episodes of metacognitive regulation

The analysis of the data provided evidence of self-, co-, and shared metacognitive regulation processes during small group and whole class inquiry activities. These forms of metacognitive regulation showed differences in terms of in which regulation phases they occurred (planning, monitoring and evaluation) and what aspects of the students' learning they focused on. The following sections illustrate evidence for the forms of metacognitive regulation identified in each of the regulatory processes of planning, monitoring and evaluation. To assist with understanding of the following episodes, please refer to Tables 5.1 and 5.2 in Chapter 5, which contain full profiles of the two focal groups of the research.

4.2.1 Planning processes

In this analysis, while the students showed evidence of engaging in co and shared metacognitive planning processes, no clear evidence of self-regulatory planning was identified. As Figure 4.1 shows, instances of co-regulatory planning processes were prevalent during both small group and whole class scientific inquiry activities and always occurred between the students and the teacher. Moreover, the students engaged in shared planning processes only during the small group activities with higher rates as compared to co-regulatory planning processes and both forms are discussed in this section with illustrative episodes.

Figure 4.1 – Average rates of the episodes of planning processes during the scientific inquiry activities



Co-regulation episodes

Co-regulatory planning episodes were identified when the students requested or the teacher provided assistance and guidance in relation to selection of an approach or procedure for performing the small group or whole class activities. These planning processes focused on either the understanding of the task goals (setting goals) or the

procedural aspects of the task (setting or clarifying conditions about the task, asking or explaining how to proceed with the learning task, or activating prior knowledge).

The following episode taken from the ‘*poisonous plant*’ small group activity exemplifies a typical co-regulatory planning process. In this activity, the students watched a three minute video clip on the interactive whiteboard about children playing football near a shrubbery and a goalkeeper accidentally touching a poisonous plant while trying to keep the ball and subsequently pulling his hand away as a reflex and then screaming. The students were instructed to watch this video clip carefully and note down their observations regarding the neural events happening in the goalkeeper’s nervous system throughout the clip. Then, all the groups were asked to explore a set of questions collaboratively by discussing each other’s observations as well as utilising the additional information and the nervous system diagram presented on the group activity worksheet. By means of this activity, the student groups were expected to explore and understand the process of reflex action and the transmission of nerve messages in the human body (see Appendix C for the student worksheet for this group activity).

In the beginning, after group B attempts to figure out how to proceed with the third question collectively (turns 1 to 5), Ezgi decides to seek assistance from their teacher (turns 6 & 10). Next, Mrs. Celin asks for more information about her request (turns 11 & 13), and provides clarification with regard to how the students can approach the group task (turns 15 & 18). Following this episode, the students begin to share and discuss each other’s ideas in relation to the inquiry question.

(Prior to Episode 4.1)

- 1 Ezgi (E): Now, third question. Brus can read it. I have read the previous one (*glances at Brus*).
- 2 Brus (B): It asks us to describe and explain the events we observed by using the nervous system model (*looking at his partners and pointing at the model*).
- 3 Vural (V): There are two events.
- 4 E: Yes. Should we explain only one event (*glances at her partners*)?
- 5 V: Well, you are the group leader (*glances at E*).

Episode 4.1 – Small group activity 4 (Group B)

- 6 E: Teacher (*raises her hand and speaks with a loud tone of voice*)?
- 7 B: Well, I am the class president (*glances at V*).
- 8 V: But she is the group leader (*smiles*).
- 9 T: (*approaches the group*)
- 10 E: Should we explain only this event on the nervous system diagram (*glances at her teacher and points at her notes*)?
- 11 T: Now, what is the most evident incident you have observed (*glances at E*)?
- 12 E: Neurons are stimulated, when the kid touches the poisonous plant (*looks at her notes*),
- 13 T: Pulling his hand away?
- 14 B: Yes, it sends a signal to the spinal cord.
- 15 T: OK (*nodding*), you can try to explain this [incident] by taking into account the reflex arc. You should explain what happens first, where the stimulus goes, where the response is created, and what the reaction is (*looks at all group members*).
- 16 E: Yes, OK (*starts writing on her notebook*).
- 17 V: Ezgi, do you really have the ability to draw (*looks at and makes fun of her*)?
- 18 T: You don't need to draw. You can explain it by using that reflex arc (*pointing at the diagram of the body*).

(After Episode 4.1)

- 20 V: I think, we can draw a small plant here and it [neural message] can come from here to here (*showing this on the model*).
- 21 E: If we write our explanation on the model diagram, it can be better, such as coming from the spinal cord to here...

In this asymmetrical form of interaction, in response to Ezgi's request, Mrs. Celin provided the group B with guidance in the terms of clarifying conditions about the task, which indicates a co-regulatory planning process. In this example, this process with the teacher facilitated the students to shape their joint planning in terms of investigating the inquiry question.

Shared regulation episodes

Incidents of shared planning processes were observed when the student groups collectively selected an approach or procedure for performing a group task. The focus of these planning processes was mostly on the understanding of shared goals or the procedural aspects of the group task (setting shared goals, setting or clarifying conditions about the group task, negotiating or assigning roles within the group, or asking or deciding on how to proceed with the group task). All these shared planning processes played an important role in building a shared understanding of the task and goals among group members which facilitated the subsequent monitoring processes.

An example of a shared planning process is illustrated in the following episode in which group A attempts to clarify one of the inquiry questions asked in the ‘*poisonous plant*’ small group activity. In the beginning, Kutay seeks consensus from his partners on moving to the next inquiry question (turn 1) and Leman suggests Ayse reads the question (turn 2). Next, after Ayse does so (turn 3), the triad attempts to clarify what they are expected to do to answer this question (turns 4 to 7). Finally, after having a shared understanding, Kutay and Leman propose a possible route for the investigation in relation to this inquiry question (turns 8 & 9). Following this episode, all the group members begin to share and discuss each other’s ideas.

Episode 4.2 – Small group activity four (Group A)

- 1 Kutay (K): Should we read the third question?
- 2 Leman (L): Ayse should read it. She hasn’t read any today.
- 3 Ayse (Ay): I am reading it, ‘*Please describe and explain the events you observed on the nervous system diagram*’(reading).
- 4 L: It asks us to demonstrate on the diagram (*glances at her partners*).
- 5 Ay: This one is our model (*pointing at the diagram*).
- 6 K: Yeah, this model.
- 7 L: Ah, OK, I thought we would draw a new model.
- 8 K: We will first describe the events on this model and explain them.
Then, we will write our explanations in our notebook (*looks at his partners*).
- 9 L: Let’s write the explanations here (*writing*).

(After Episode 4.2)

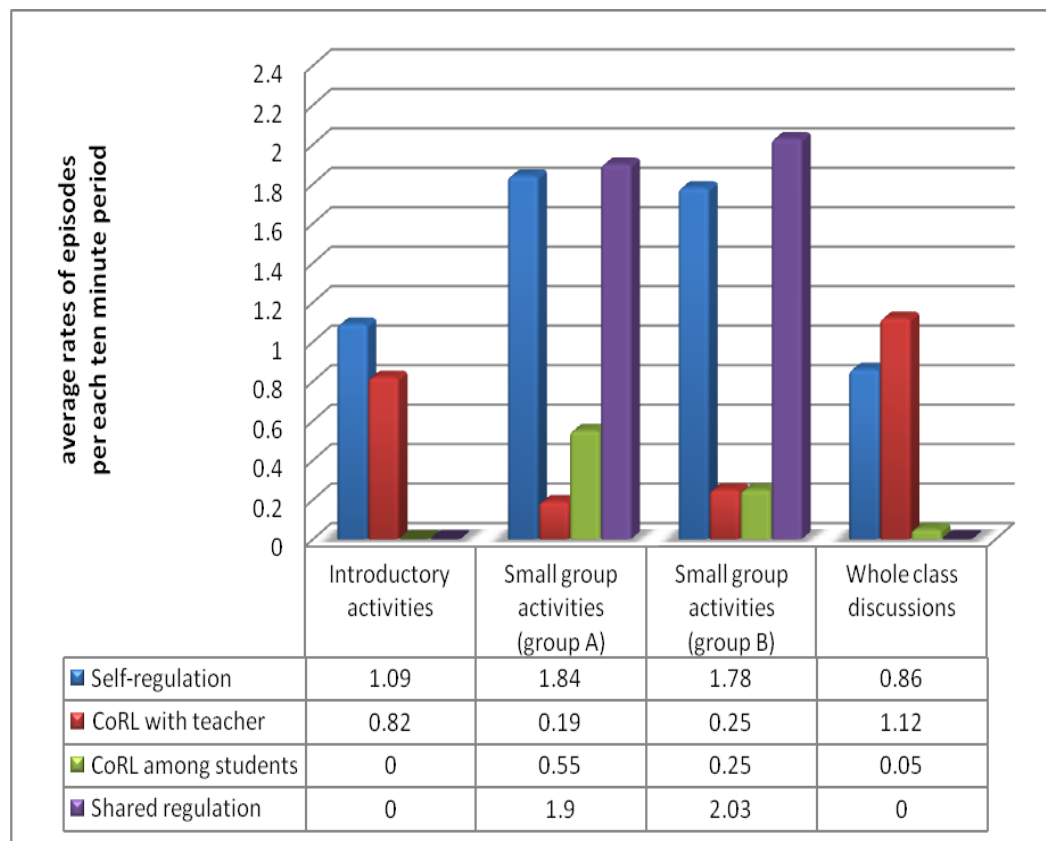
- 10 Ay: Hang on Leman! Don't study individually.
11 L: OK.
12 T: Class, you have five minutes to finish your group work.
13 K: That's cool! We can easily finish it (*speaks with an encouraging tone of voice*). Now, it touches this tissue here. So as we explained...

The analysis of interactions in this example shows evidence of a shared planning process. In turns 1, 2 and 3, the students made a joint decision on proceeding with the learning task, which shows as a planning process. Moreover, in turns 4 to 7, the triad interpreted and clarified the conditions regarding the inquiry question in order to comprehend what was expected in their joint task, which also indicates another planning process. Lastly in turns 8 and 9, in the light of a shared understanding of the question they had arrived at, the students decided on a possible way of proceeding with the learning task, also indicating another shared planning process. It is evident in this dialogue that group A collectively planned their joint activity by means of reciprocal interaction. These shared regulation processes had the function of promoting the ongoing activity through creating a joint plan and shared understanding of the task among the group members.

4.2.2 Monitoring processes

Regarding this analysis, the students showed evidence of engaging in self-, co-, and shared metacognitive monitoring processes. As Figure 4.2 illustrates, unlike with the planning processes, the students showed evidence of individual monitoring processes during small group and whole class inquiry activities. Also, evidence of co-regulatory monitoring processes among students was visible mostly during small group activities, whereas the students engaged in co-regulatory monitoring processes with their teacher in all the types of activities. Finally, shared monitoring processes were identified only during the small group activities. All forms of monitoring processes are discussed in this section with illustrative episodes.

Figure 4.2 – Average rates of the episodes of metacognitive monitoring processes during the scientific inquiry activities



Self-regulation episodes

Evidence of self-regulatory monitoring episodes was identified as when an individual student checked or assessed his/her own current understanding or monitored his/her own progress during both small group and whole class activities. In some instances, these processes appeared to influence the direction of the small group activity.

The following episode taken from the '*water content of our body*' small group activity exemplifies a typical self-regulatory monitoring process. In this activity, in order to understand the importance of the nervous system, endocrine glands and kidneys in the regulation of body conditions, the groups investigated how the water level in human body is adjusted and what processes occur during the filtration of blood in the kidneys. The groups were asked to explore a set of questions through examining three diagrams each of which showed different levels of water and anti-diuretic hormone (ADH) in the human body, the information about the functions of

the hypothalamus and ADH hormone, and the structure of the kidney (see Appendix C for the student worksheet of this group activity).

Prior to this episode, group B was brainstorming for one of the inquiry questions about how the water level in the human body is adjusted during the excretion process. In this episode, after Brus's attempt to move to the next question, Vural expresses awareness of his lack of understanding of the previous question, while speaking slowly with a puzzled facial expression (turn 4). Following this episode, an assessment of his current understanding leads his group to discuss more about the adjustment of the water level in the human body.

(Prior to Episode 4.3)

- 1 B: The third question.
- 2 V: Please be quiet.
- 3 B: Says 'What processes occur during the filtration of the blood in the kidneys?' (*reading*).

Episode 4.3 – Small group activity five (Group B)

- 4 V: One second, but, I still don't understand the previous question. Here (*points at the diagram*), um, how can the kidneys detect whether the water level increases or decreases (*speaks slowly, appearing to be puzzled*)?

(After episode 4.3)

- 5 B: Kidneys.
- 6 V: Stop talking.
- 7 B: Do the kidneys actually detect and send signals (*looking at his partners*)?
- 8 V: Yeah, here it sends a signal to the hypothalamus (*points at the diagram*).
- 9 E: So, you mean the hypothalamus secretes the ADH hormone?

In this example, Vural's first utterance indicates an individual monitoring process in which he made a judgment of his understanding. That is, it is clearly evident that this utterance only focuses on his individual understanding of the content and hence this

example provides evidence of a self-regulation process in which he monitored his own cognitive processing.

Co-regulation episodes

For co-regulatory monitoring processes, the students or the teacher usually checked or provided assessment of another student's conceptual understanding or monitored another student's actual progress via questions, prompts and explanations in a variety of brief asymmetrical interactions. The focus of these monitoring processes was usually on a student's understanding of the task content (also see Section 6.3 for more illustrative episodes).

The following episode exemplifies this type of monitoring process. Prior to this episode, just before the whole class discussion in which the students would share their ideas for the inquiry questions investigated in the '*poisonous plant*' small group activity, group A has been revising their answers one last time. In the beginning, after getting Leman's attention and articulating his lack of understanding, Kutay seeks help from Leman about how one of the events identified in their observations is carried out by the nervous system (turns 1 & 3). Next, Leman looks at Kutay and provides an explanation of what happens in the nervous system when the child in the video clip touches the poisonous plant (turn 4). Then, Kutay attempts to clarify what he understands from Leman's explanation, requesting an assessment of his comprehension (turn 5). In response, Leman glances at Kutay and provides a judgment of his understanding (turn 6). In the last turn, Kutay appears to acquire new understanding regarding the topic.

Episode 4.4 – Small group activity 4 (Group A)

- 1 K: Leman, I will say something (*looking at L*).
- 2 L: (*glancing at K*)
- 3 K: You know, he pulls his hand away first and then screams. I don't understand this really. What is he doing there, a reflex (*smiles*)?
- 4 L: Firstly, he pulls his hand away as a reflex, and then the impulse goes to the brain, and the brain tells him to scream and so he screams (*looking at K*).
- 5 K: Yeaah (*a rise in the volume of his voice*)! It goes to the brain (*pointing at his brain*), doesn't it? First, it goes to the brain by means of the

spinal cord, and the reflex happens through the neuron cells (*using gestures and looking at L*).

6 L: No. After he pulls it away (*glances at K*).

7 K: Yeah, OK (*checking his notebook for two seconds*). I have got it correctly (*nodding*).

As can be seen in this episode, after Kutay communicated his lack of understanding which created intersubjectivity with his partner, Leman provided him with assistance to clarify his thinking and construct new understanding by means of engaging in a co-regulatory monitoring process. During these asymmetrical interactions, Leman monitored Kutay's understanding and was able to respond coherently to changes in his thinking.

The next episode taken from a whole class discussion also presents an example of co-regulatory monitoring with the teacher. Previously, the class was discussing ideas about the time when the sleep-wake cycle is perceived by babies. At the beginning, Mrs. Celin calls upon Kutay to share his idea about this issue (turn 1). Then, he makes an assessment of his own understanding and presents his viewpoint which reveals a misconception held by him (turn 2). After realising his misconception, Mrs. Celin poses questions in order to stimulate Kutay to rethink about his initial idea (turns 3 & 5). Next, while Kutay accepts Mrs. Celin's perspective, he seems to insist on the accuracy of his initial idea (turns 4 to 8). In the end, Mrs. Celin provides an elaboration on his misconception and gives an explanation about the sleep-wake cycle (turns 7 & 9).

Episode 4.5 – Whole class discussion 3

1 T: OK. Kutay, do you remember (*looking at K*)?

2 K: (*stands up*) I can't really remember, but I have an idea like this. It may begin in the mother's womb. Because when the mother sleeps, the baby also has to start sleeping. Because the mother cannot deliver food to the baby, then.

3 T: Why is this? Um, doesn't mother's heart beat when she sleeps?

4 K: It beats but,

5 T: Don't her lungs work?

- 6 K: Working, but she doesn't spend too much energy.
- 7 T: I think, as long as they [hearts and lungs] work, the blood is conveyed to the baby from mother. And if the blood goes, the baby also gets oxygen and nutrition.
- 8 K: But.
- 9 T: OK, this cycle begins in mother's womb when the brain functions of the baby start. So the sleep-wake cycle usually begins six months after conception in the mother's womb...

The analysis of these interactions shows that Mrs. Celin was aware of as well as able to respond to ongoing changes in Kutay's thinking by engaging in co-regulation. After exploring his misconception, she challenged his thinking and asked him prompting questions to reflect on his initial idea, instead of just giving a direct corrective feedback. In response, Kutay monitored his understanding, which then revealed further information about his comprehension. Lastly, Mrs. Celin provided a judgement of his thinking by elaborating upon his idea. This co-regulation process was aimed at helping Kutay become aware of his misconception as well as facilitating his construction of a new conceptual understanding.

Shared regulation episodes

Incidents of shared monitoring processes were observed when the students checked, assessed or made a judgement of their group's conceptual understanding or monitored the actual group progress being made towards achieving a shared goal through reciprocal interactions, in which they usually took into consideration each other's ideas as well as remained open for the negotiation of the ideas put forward. These monitoring processes mainly focused on understanding of the content or actual performance of the group task. While shared monitoring processes mostly played an important role in fostering and facilitating a group's conceptual understanding, there were also a few instances in which engaging in shared monitoring slowed down the continuation of the ongoing group discussion. In addition, some of these monitoring processes appeared to be influential in changing or constructing a new joint plan for the group tasks (see Section 6.4 for more illustrative episodes).

The next episode which comes from the ‘*football match*’ small group activity exemplifies this type of monitoring process. In this group activity, the students were asked to watch a short video clip of a football match on the interactive whiteboard and write down their observations about the events that occur around and inside a footballer’s body. Subsequently, they were instructed to work in groups to answer and discuss a set of inquiry questions by using their observations. The aim of this activity was to engage them in exploring the importance of the nervous system for the functioning of other human body systems and the coordination which exists among all the systems in the human body (see Appendix C for the student worksheet of this group activity).

In this part of the activity, group A attempts to assess whether the human body systems performing the events they identified from their observations function independently or not by discussing and sharing ideas with each other. First, Kutay presents his viewpoint and Leman and Ayse express agreement with his idea (turns 2 to 4). Next, they begin to co-construct new knowledge by confirming and justifying their ideas, while also simultaneously monitoring their collective understanding. For instance, after reaching consensus on a joint answer, all three provide a rationale for their collective thinking by elaborating upon their ideas. This indicates monitoring processes in which they check and assess their mutual understanding (turns 5 to 8). Also, in turn 9, Ayse seeks consensus one last time on their mutual understanding by summarising their discussion in the form of an implied question. Finally, at the end of the episode, all the group members begin to write their joint answer.

Episode 4.6 – Small group activity three (Group A)

- 1 L: So, ‘*do the systems performing these events function independently?*’
(*reads the question*).
- 2 K: No (*glances at Leman*).
- 3 L: I agree.
- 4 Ay: No, they are interdependent (*takes a note*).
- 5 K: Yes, because for instance, first our brain notices, then we make our physical act (*looks at his partners*). Or we can also do the physical act according to our reflexes.

- 6 L: That's right. For example, first we see and then this information travels to our brain (*points at her brain while looking at her partners*). In the brain, it either becomes a reflex or in response to it, we can run away (*starts writing*). So, they are interdependent.
- 7 Ay: Now, when I make as if to stab this pencil in your arm (*shows with her pencil*), you first see it and then pull yourself away (*pulls herself away from the desk*).
- 8 K: Yes (*nodding*), first you create the reflex then you do the physical act. At that moment, you are also thinking (*points at his brain*).
- 9 Ay: So, it seems everything is dependent on the brain (*looks at her partners and her tone of voice indicates an implied question*)?
- 10 L: Yeah.
- 11 All: (*start writing*)
- 12 L: Now, we feel through our senses...

In this episode, group A was presented with opportunities to co-construct new knowledge by building on and discussing each other's ideas. The students remained open-minded, attentively listening and respecting each other's viewpoints and contributions. Moreover, they collectively regulated their cognitive processing towards a mutual goal through monitoring their shared understanding, which would not be possible without their reciprocal interaction. In turns 5 to 10, their utterances and non-verbal actions indicate monitoring processes in which the group's learning is jointly monitored through checking and assessing their understanding. These shared monitoring processes performed the function of facilitating the ongoing group discussion. This example suggests evidence of shared regulation, since this interaction is geared towards influencing the group's shared cognitive processing.

Another example of a shared monitoring process is illustrated in the following episode which slows down the continuation of the ongoing discussion. In this episode, while group A has already seemed to agree upon a possible joint answer for the first inquiry question in the '*football match*' small group activity, they continue to discuss certain aspects of their ideas by reflecting on their shared understanding.

At the beginning, considering the joint answer they agreed upon, Leman presents her idea of which events take place when a footballer scores a goal. In response to this explanation, Ayse expresses disagreement and challenges her to justify her thinking (turn 15). Next, while Leman presents an elaboration on her suggestion (turn 16), this does not convince Ayse and this leads on to her asking another question, which invites her partners to reflect on their thinking (turn 17). Next, Kutay makes an inference which contradicts Ayse's viewpoint (turn 18). Then, Ayse articulates her understanding in order to clarify why she cannot agree with Leman's explanation (turns 22 to 24). This episode ends without reaching any visible consensus amongst the students on their ideas.

(Prior to Episode 4.7)

- 1 K: 'How many events can occur around and inside a person's body who is playing football?' Can I answer this?
- 2 Ay + L: Yes (*nodding*).
- 3 K: Now, first of all, there are physical events, such as running. And there are also mental events (*pointing at his brain*). Those are reasoning, because football requires reasoning. If you don't have, you cannot be successful. So they are using physical, but also mental processes. There are 3 types of events happening around and inside a footballer's body. First is physical, running, second is mental, thinking, and the third one is passing the ball. Um sorry it is actually two (*smiles*).
- 4 L: What about you (Ayse)?
- 5 Ay: I agree that there are two types.
- 6 L: I think, there are actually three types of events.
- 7 K: So, tell us?
- 8 L: Firstly, there is physical such as running and defending, and there is a reflex one, as they are trying to keep the ball. There is also a neural event, as they are thinking and playing.
- 9 K: I think just two,
- 10 L: Actually, in my opinion, as we have watched in this video, when a few rival footballers approach,
- 11 Ay: It is physical, isn't it?
- 12 L: A need emerges to pass the ball more quickly.

- 13 K: So accordingly, there should be three types of events. We have said reflex, physical and mental.

Episode 4.7 – Small group activity three (Group A)

- 14 L: For instance, when scoring a goal if you are good enough (*looks at her partners*), there is a reflexive event, and then there is also a physical one (*takes a note*).
- 15 Ay: Leman, scoring a goal is not a reflexive event. How can we score with our reflexes?
- 16 L: No, what I mean by scoring is (*smiles*), for example, when there is no one in the goal area you can try to score. Or you are the goalkeeper, so it can be also keeping the ball (*uses specific hand gesture while explaining*). OK?
- 17 Ay: No, this event is actually physical. Do you jump suddenly as a goalkeeper when the ball comes (*shows how to jump*)?
- 18 K: Yes, it is a reflex (*glances at his partners*).
- 19 L: Yes.
- 20 Ay: No, it is not, one moment. When someone approaches, you either keep the ball,
- 21 K: Pass the ball.
- 22 Ay: Or pass the ball.
- 23 L: Yes, OK but...
- 24 Ay: This actually becomes a mental process (*speaks to Leman*). When someone sees the goal area empty, he doesn't pass the ball as a neural event. So, there is nothing like scoring a goal with a reflex.

(After Episode 4.7)

- 25 T: (*she approaches to the group*) Alright, what else happens, running, sweating?
- 26 K: They are physical.
- 27 Ay: Physical.

The group stimulated-recall interview provides an additional insight into the processes occurring during this particular episode. That is, in the group interview, the

students were able to articulate what they were doing and thinking during their interactions and engagement with the group task. This provided evidence that they were aware of each other's thinking and had a shared understanding of what they were discussing and negotiating. In turns 2 and 7, Ayse's comments show that she was conscious of her partners' ideas and assessed group understanding by comparing it with her own thinking. Likewise, Kutay and Leman were also able to describe what they were thinking during this episode. For instance, in turn 11, Kutay's interview comments showed his awareness and judgment of his own and shared ideas. This analysis of the stimulated-recall group interview provides evidence that the students were aware of their individual thinking as well as that of the group, and that they engaged in reciprocal and shared processes at the metacognitive level.

Stimulated-recall interview 4.1 – Group A

- 1 I: OK, Ayse, let's discuss what's happening here?
- 2 Ay: Now, here, what Leman was telling us seemed completely inappropriate to me. Like when the ball comes in front of a footballer, the person cannot kick the ball as a reflex without thinking.
- 3 I: OK.
- 4 L: I thought when the person sees the goal area empty, he would score.
- 5 K: Yeah, but the goal area wasn't empty, there was a wonderful goalkeeper.
- 6 I: OK, let's watch it again... (*all watching again*)... You are discussing here... Now, first of all, I will take Ayse's viewpoint on this incident before yours.
- 7 Ay: I am still trying to defend my idea there. Kutay also says something close to Leman's suggestion, but I thought someone cannot pass the ball as a reflex.
- 8 K: But eventually, if you are not Ronaldinho or someone else and when several people are coming towards you, you might kick the ball as a reflex.
- 9 L: I also thought like this.
- 10 I: Kutay, what were you thinking here?

- 11 K: I was thinking that there should be some events involving our reflexes, but I also didn't agree with what Leman was saying. Now like scoring when the goal area is empty. I thought these events were mental.
- 12 I: What did you think Leman?
- 13 L: I thought, when some sees the goal area empty, they feel a sudden need to score, or as Kutay said, if someone comes, they can also pass the ball instantly. I was thinking of it as a reflex.
- 14 I: OK, let's continue.

In this example, as the analyses of video and stimulated-recall interview data reveal, while Leman was remarking upon the joint answer agreed on previously, group A experienced conflicting ideas which slowed down the ongoing process of knowledge co-construction. Subsequently, the students engaged in shared monitoring processes to check and assess their joint understanding by articulating their thinking and challenging each other's ideas to justify and clarify their overall perspective. However, in the end, they were unsuccessful in terms of reaching a mutual understanding.

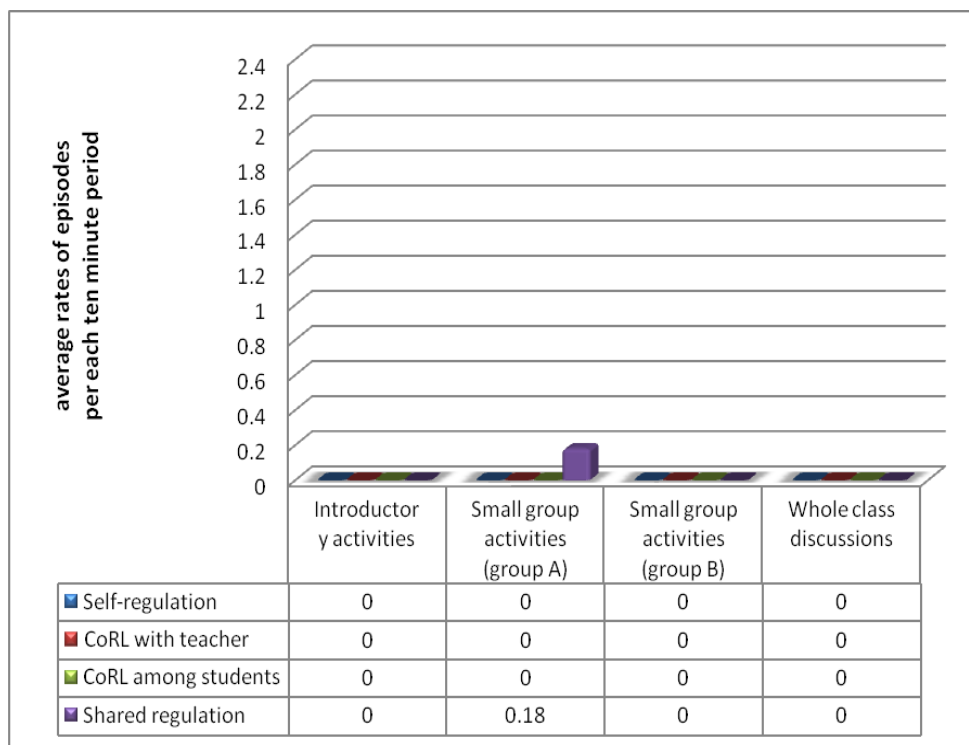
4.2.3 Evaluation processes

While the analysis revealed that the students showed evidence of engaging in a few shared evaluation episodes, no clear evidence was identified in relation to self and co-regulatory evaluation processes. Also, as shown in Figure 4.3, the episodes of shared evaluation process were only observed during the small group activities performed by group A, with relatively low rates compared to shared planning and monitoring episodes. The shared evaluation processes are discussed in this subsection with an illustrative episode.

Shared regulation episodes

There were only a few instances of shared evaluation processes, which were usually observed when the students attempted to review their group's overall learning during the small group activities. The following episode taken from the '*football match*' small group activity exemplifies this type of shared evaluation process.

Figure 4.3 – Average rates of the episodes of metacognitive evaluation processes during the scientific inquiry activities



Prior to this episode, the students have been sharing and discussing each other's ideas with regard to the last inquiry question of the task. After agreeing upon a mutual answer, Leman suggests that she and her partners review all their answers before the end of the group activity (turn 7). Next, Leman and Ayse start summarising and affirming the main points of their answers to the inquiry questions for the group task (turns 7 to 10). This episode ends when Mrs. Celin calls upon all the groups to engage in whole class discussion (turn 11).

(Prior to Episode 4.8)

- 1 L: They (*systems*) are controlled in different parts of our brain.
- 2 Ay: Different sections (*writing*).
- 3 K: In the brain.
- 4 L: Perceived in different parts or sections of the brain,
- 5 Ay: OK (*nodding*).
- 6 L: they are being stimulated.

Episode 4.8 – Small group activity three (Group A)

- 7 L: Now, let's talk from the beginning (*glances at her partners*). For the first question, we suggested three types of events, for which we can give different examples when considering our daily lives.
- 8 Ay: (*nodding*) For the next question, we proposed that neural events are performed by the nervous system, physical events are performed by the skeletal system, and mental events are carried out by the brain.
- 9 L: Yes, then we said that those systems are interdependent.
- 10 Ay: Yes.

In this episode, after the students had answered all the inquiry questions of the group task, they decided to make an evaluation of their achievement by reviewing their answers together. This reciprocal interaction indicates a shared evaluation process, as the students were focused on reviewing their joint understanding towards achieving shared goals.

4.3 Episodes of motivational and emotional regulation

The analyses of the data set also provided evidence of self-, co-, and shared motivational and emotional regulation processes during the small group and whole class inquiry activities. The forms of these regulation processes showed differences in terms of in which regulation phases they occurred (monitoring or control) and what aspects of the students' learning they focused on.

As the Figures 4.4 and 4.5 show, there was evidence of self-regulatory emotional and motivational monitoring episodes across all types of inquiry activities, while self-regulatory control processes were observed only during whole class discussions and the small group activities carried out by group A. In terms of co-regulation episodes, while episodes of co-regulatory control processes between the teacher and students were identified across all types of activities, there was no evidence of a monitoring process. Concerning shared regulation episodes, control processes were identified during both introductory and small group inquiry activities, whereas only group A engaged in shared monitoring processes during the latter.

Figure 4.4 – Average rates of the emotional and motivational monitoring episodes across the types of activities

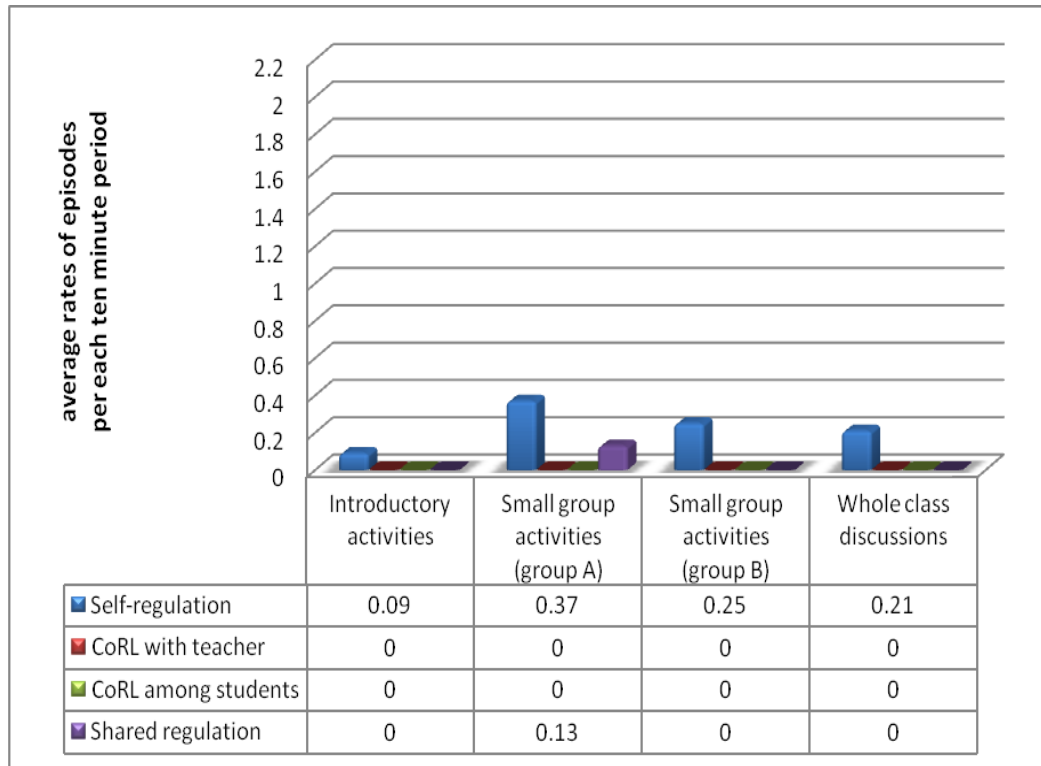
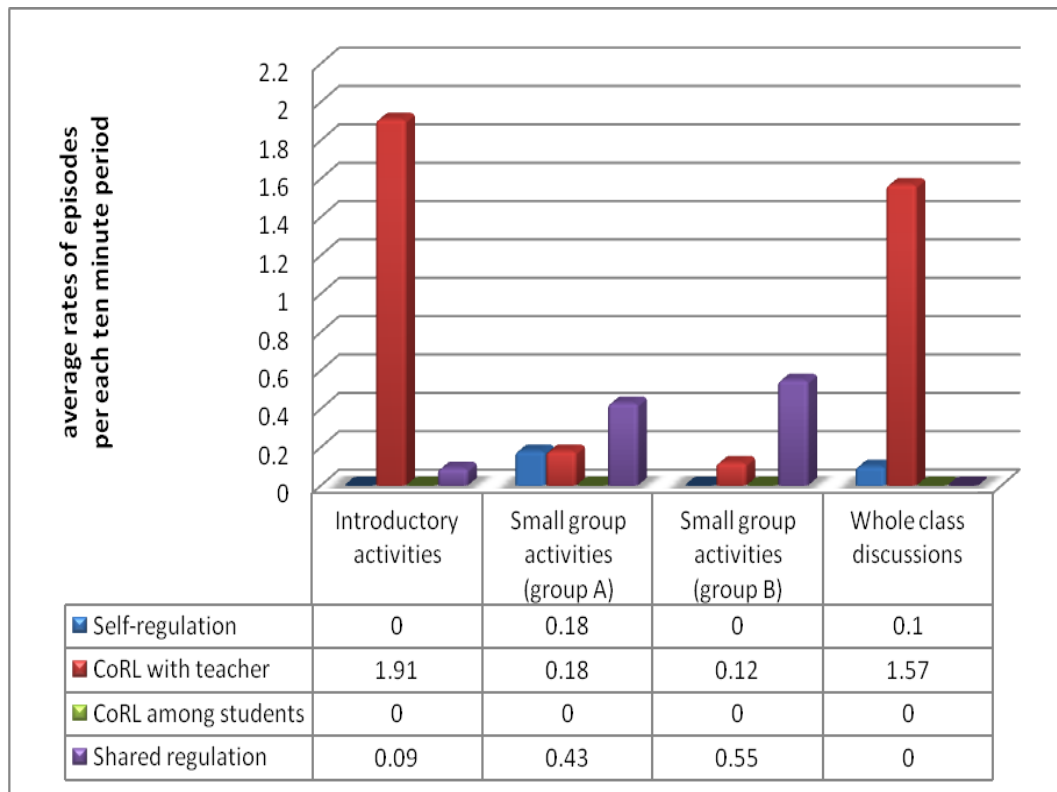
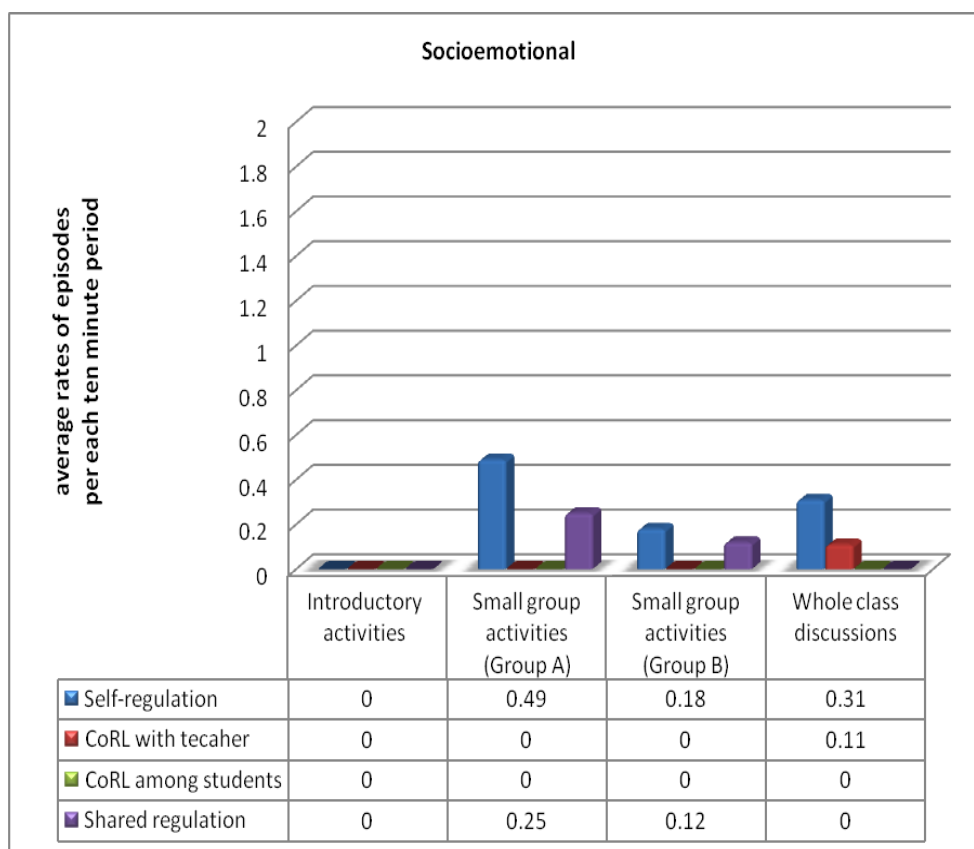


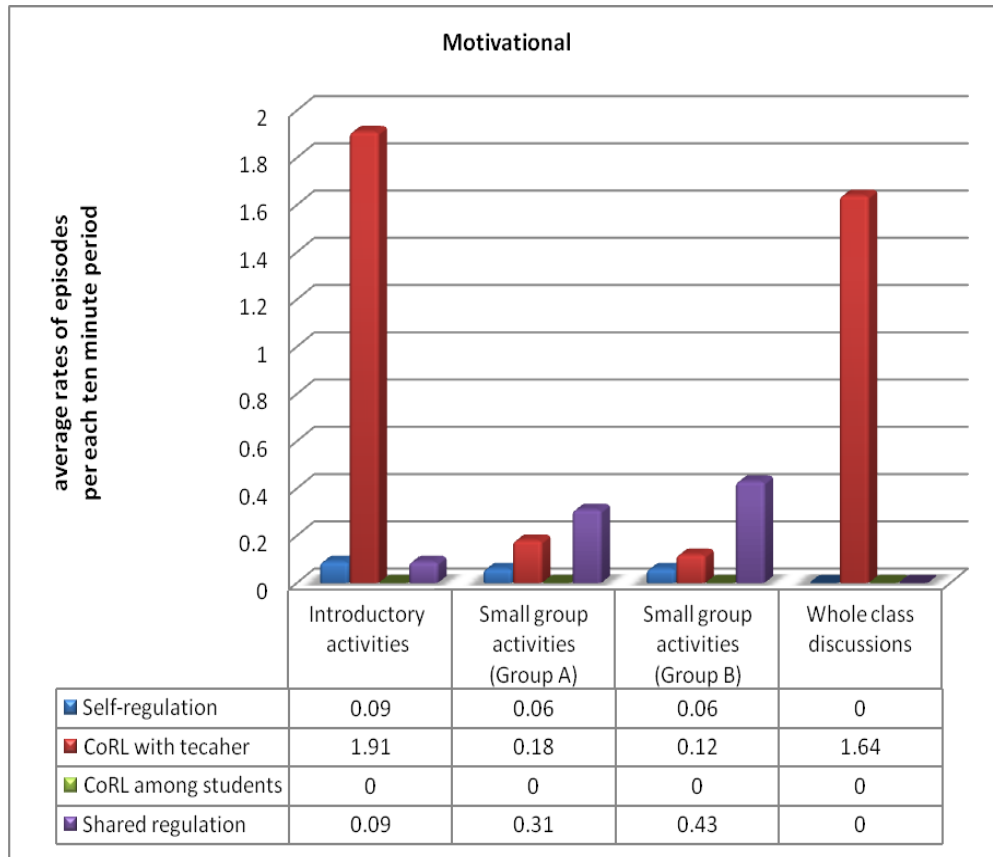
Figure 4.5 – Average rates of the emotional and motivational control episodes across the types of activities



Furthermore, as Figure 4.6 reveals, the emotional and motivational regulation episodes focused on either socioemotional or motivational aspects of the students' learning. In the episodes focusing on the former aspect, the students always expressed awareness of a negative emotional experience (such as, annoyance, embarrassment, boredom or disappointment) which mostly emerged through social interaction with others (such as, experiencing contradictory views, making a mistake in front of others, or having different goals or priorities), and controlled these negative emotional experiences individually or socially. In the episodes which focused on the motivational aspect, the students expressed awareness of their experiences (such as lack of interest or wonder towards the task or facing difficulty or distraction while engaging with the task), and controlled these experiences individually or socially by using a variety of strategies. Self and social forms of emotional and motivational regulation are discussed in this section with illustrative episodes.

Figure 4.6 - Average rates of the emotional and motivational regulation episodes in terms of their focus





4.3.1 Self-regulation episodes

Evidence of self-regulatory monitoring and control processes was identified when a student expressed awareness of his/her own negative emotional and motivational experience or reaction, and attempted to control these individually during the scientific inquiry activities. The following episode taken from the '*football match*' small group activity exemplifies emotional and motivational self-regulation.

At the beginning, group A attempts to investigate which system or systems in human body perform each of the events they identified in their observations. After reaching consensus on their ideas about reflexes (turn 2 to 4), Kutay suggests cells as being responsible for performing the physical events in the human body and attempts to justify his idea (turn 5). However, Leman glances at him and expresses disagreement by presenting a contradictory idea (turn 6). While Kutay seems to acknowledge Leman's point, he decides to seek help from his teacher with a smiling face and a hesitant tone of voice (turn 9). Next, Mrs. Celin clarifies Kutay's misunderstanding by telling him that the question is actually about systems, not cells (turn 12).

Subsequently, Kutay acknowledges his misunderstanding and looks confused and cheerless, putting his left hand on his cheek and his pencil into his mouth (turn 13). At the end of this episode, Kutay attempts to look at another aspect of the question, while also checking if the teacher is still listening to the group discussion (turn 15). After this incident, group A carried on with their discussion, but Kutay remained silent for a minute or two before contributing again.

Episode 4.9 – Small group activity three (Group A)

- 1 T: *(she is listening to the group conversation and standing next to Kutay)*
- 2 K: Reflex is being performed by the nervous system.
- 3 Ay: Yes *(nodding)*.
- 4 L: Nervous system.
- 5 K: For physical events, I think, our cells are involved. Because we need energy and we supply our energy through mitochondria which is in our cells.
- 6 L: It is the skeletal system *(while writing, she raises her head and looks at Kutay)*.
- 7 K: Sorry *(pays attention to Leman)*?
- 8 L: Skeletal system.
- 9 K: Yeah, possibly *(with a puzzled face)*. Teacher, isn't the energy provided by our cells *(smiles and talks to the teacher with a hesitant tone of voice)*?
- 10 T: Yes.
- 11 K: OK.
- 12 T: But we are talking about systems not cells.
- 13 K: Yes, right, skeleton system *(looks confused and displeased - he touches his chin with his left hand and puts his pen into his mouth)*.
- 14 T: *(she leaves the group)*
- 15 K: So, which one is performing the mental events *(turns back and checks if the teacher is still listening to them)*?

In this episode, Kutay faced a socioemotional challenge as a result of a co-regulatory monitoring process, which revealed an inconsistency in his own and his fellow group member's ideas, and subsequently attempted to regulate his emotional and

motivational states individually. In this analysis, his utterances and nonverbal actions in turns 9 and 13 show his awareness of his negative emotional experience. Also, his utterance and nonverbal actions in turn 15 indicate a process of controlling his negative emotional experience by means of trying to shift everyone's attention to another aspect of the inquiry question.

Stimulated-recall interview 4.2 – Group A

- 1 I: What was happening here, Kutay?
- 2 K: Here, Mrs. Celin and Leman didn't agree with me and I faltered a little bit.
- 3 I: For instance, what was your understanding firstly and what happened then?
- 4 K: I assumed that I had answered this question correctly, but when Mrs. Celin said it was like this. I was uncomfortable a little bit because of making a mistake.
- 5 I: For example, you first mentioned about cells but it was actually about systems.
- 6 K: Sir, my brain works really differently.
- 7 I: Yes.
- 8 K: I perceive everything so differently, for instance. Celin teacher once told us that our body does not have any power plant (...) so I made this explanation about cells and mitochondria.
- 9 L: And I thought it was skeletal system.
- 10 I: Then.
- 11 K: Mrs. Celin came and told it like this.
- 12 L: When he heard the teacher, he just did not insist on his previous answer and dropped the subject.
- 13 K: Yeah, she [teacher] told me so and I dropped the subject right away, although I didn't fully understand her.

The stimulated-recall group interview also presents evidence supporting this interpretation. As can be seen from the excerpt above, when Kutay was asked what he thought about this incident, he explained that he felt a little bit uncomfortable because of having an incorrect view which was discussed by his teacher and a fellow

group member. Also, he explained that he wanted to change the direction of the ongoing discussion in order to avoid the situation he was in, even though he did not fully understand Mrs. Celin's explanation. Both of these analyses present evidence of self-regulation, because his regulatory behaviour focused on only his own emotional and motivational states.

4.3.2 Co-regulation episodes

Evidence of emotional and motivational co-regulation processes was identified, when the teacher attempted to control student(s)' motivational and emotional states during the scientific inquiry activities. These co-regulatory processes helped them sustain successful engagement with the inquiry tasks as well as contributing positively to the socioemotional atmosphere of the classroom. The following episode taken from an introductory activity to the subject of the nervous system provides an example of this form of regulation.

In this activity, the students are asked to formulate one or two inquiry questions which they wonder about the nervous system, which they then share with the whole class. At the beginning, after getting permission from Mrs. Celin, Vural presents his own inquiry question that he wishes to investigate (turn 2). Next, after Mrs. Celin restates his question, she calls upon other students to respond, but none of them shows any willingness to share their ideas (turns 3 & 4). After a few seconds of silence, Mrs. Celin praises the ideas presented earlier and encourages others to express their viewpoints (turn 5). Then, Kutay raises his hand and Mrs. Celin allows him to share his inquiry question (turns 6 to 9). Eventually, as a result of this encouragement, other students also start showing a willingness to share their questions.

Episode 4.10 – Introductory activity 2

- 1 T: Vural?
- 2 V: Why do most of our nerves pass through our spinal cord?
- 3 T: "Why do most of our nerves pass through our spinal cord?" (*nodding*)
OK, anything else?
- 4 All: (*no answer from the students, a few seconds of silence*)

- 5 T: We are having really good questions at the moment (*smiles while looking at whole class*). Come on (*the volume of her voice rises*)!
- 6 K: (*raises his hand*)
- 7 T: Kutay.
- 8 K: Mine is easy, teacher. Um, what is a neuron and what is its function?
- 9 T: Good (*nodding*), Ege

In this example, Mrs. Celin attempted to promote a positive atmosphere, as a result of sensing a lack of engagement of the class with the task. In turn 5, her utterance, facial expression as well as tone of voice indicate a process of controlling the motivational states of the class through encouraging active engagement and confidence towards the activity. Her regulatory behaviour became successful in terms of introducing a positive emotional atmosphere into the classroom, which resulted in the students showing increasing motivated engagement with the learning task. This episode presents evidence of a co-regulation process since the teacher's regulatory behaviour is aimed at influencing the students' motivation towards the inquiry task.

In the next episode, the teacher and students engage in a whole class discussion in relation to the '*poisonous plant*' small group activity. In this part of the discussion, the students have been sharing their ideas about why the spinal cord does not send a message to the brain when the child pulls his hand away after touching the poisonous plant. In the first turn, after getting permission from her teacher, Zeynep expresses an agreement with her friends and gives a funny example which causes the whole class to laugh. Also, Mrs. Celin smiles and makes a joke about her example and some other students attempt to make fun of her (turns 3 & 5). Next, Zeynep completes her explanation and asks her teacher a question, with a smiling and blushed facial expression. Then, Brus continues to make fun of her about her idea again with a sarcastic tone of voice (turn 7), but Mrs. Celin interrupts him and talks about his misunderstanding (turn 8). Then, she attempts to shift the class's attention to another issue without answering Zeynep's question.

Episode 4.11 – Whole class discussion 4

- 1 Z: Teacher, I agree with everyone's idea. Now, I will give an example.
For instance, you are walking on the street, and coming across a bomb,
then.
- 2 All: (*laughing*)
- 3 T: Yes, it is something we encounter very often (*smiles*).
- 4 K: Is she joking (*laughing*)?
- 5 B: Yes, we find it every day on the road (*laughing*).
- 6 Z: Teacher, do you think when we see the bomb it is better to wait and say
'Ah' and run away or to run away immediately (*smiles and looks at her
friends with a blushed face*)?
- 7 B: So, how will you know that there is a bomb? Maybe there is something
else inside the bag (*with a sarcastic tone of voice*)?
- 8 T: She didn't mention a bag, just said a bomb (*walks and shakes her head
while glances at Brus*). Alright, do any of you have any queries about the
questions we have just looked at?

In this incident, Mrs. Celin engaged in a process of controlling Zeynep's emotional state as she was likely to experience a socioemotional challenge that emerged while sharing her view with the class. In turn 6, the sudden momentary changes in the facial expressions and body language indicate Zeynep's awareness of a negative emotional experience, which indicates a self-regulatory monitoring process. In turn 8, Mrs. Celin's verbal and nonverbal behaviour indicate a process of controlling Zeynep's emotional state through supporting her against others as well as shifting everyone's attention to another issue. This regulatory behaviour provides evidence of co-regulation, whereby Mrs. Celin aims to influence Zeynep's emotional and motivational engagement with the learning task.

4.3.3 Shared-regulation episodes

The students also engaged in shared emotional and motivational monitoring and control processes during the scientific inquiry learning activities. That is, they were explicitly able to express social awareness of these processes and employed various strategies to cope with them. These regulatory processes played a crucial role in

sustaining reciprocal interactions among group members, increasing group cohesion as well as shaping and constructing the socioemotional atmosphere of the groups.

An example of a shared regulation process is illustrated in the following episode, which comes from the '*Journey of food*' small group activity. In this activity, the student groups were asked to watch a short video clip about the digestive system process on the interactive whiteboard and note down their observations. Then, they were asked to select two types of food as a group and describe how they are digested in the human body through answering a set of questions and examining the digestive system diagram presented on the group activity worksheet. At the end of this activity, the students were expected to understand and explain the functions of digestive enzymes and assistive organs during the digestion process as well as how the nutritional contents are digested and absorbed into the bloodstream in the human body.

In this part, before the group work starts Mrs. Celin asks the groups to formulate an inquiry question which they wonder about the digestive system. At the beginning of the episode, in relation to identifying such a question, Brus expresses a lack of enthusiasm as he thinks that he has learnt almost everything he wants to know about the digestive system (turn 8). In response to Brus, while Vural remains silent, Ezgi glances at him and attempts to encourage her partners to think about a question together, speaking with an enthusiastic tone of voice (turns 9 & 11). In turn 12, Mrs. Celin provides more information about the type of question the groups are being asked to generate. Following Ezgi's suggestion to examine the human anatomy model, Vural stands up and shows a willingness to examine the liver on the model (turn 14). Then, Ezgi praises Vural's behaviour and all of them leave their desk to look at the human anatomy model (turn 15). Following this episode, the group members start sharing and discussing their questions and ideas, including Brus.

(Prior to Episode 4.12)

- 1 T: Think about a question about this subject that you wonder about
(speaking to the whole class).
- 2 B: Teacher, are we going to find this question as a group or?
- 3 V: Yes.

- 4 T: Yes, you will discuss what you wonder about regarding this topic.
5 V: Can we look at the books?
6 E: No.
7 T: No, you must think (*glances at V*).

Episode 4.12 - Small group activity two (Group B)

- 8 B: Actually (*looking at the partners*), I have had a lot of questions at the beginning, but I have learnt almost everything. Now, I don't really wonder about anything.
9 E: But let's think together, let's force our imagination (*glances at B and speaks with an enthusiastic tone of voice*). The most interesting questions always come from Vural (*glances at V*). Let's first listen to him. He may actually stimulate our mind too.
10 V: Um, um (*thinking*).
11 E: OK, everyone is thinking (*puts her hands on her chin and pretends to think*).
12 T: Everybody, it will be a type of researchable question, rather than one seeking factual information, such as the tasks of liver or stomach. It must be one that requires you to make some interpretations and to make you think critically.
13 E: Let's look at the model now.
14 V: Good, I will examine the liver (*stands up and walk towards the model*).
15 E: Yeah, that's brilliant. Let's look at the model while thinking (*all leaving their desk to look at the human anatomy model*).

(After Episode 4.12)

- 16 B: I have found [a question], why does the food sometime goes into throat rather than the pharynx?
17 V: It is because you are trying to speak while eating.
18 E: Yes, if you speak while you are eating.
19 V: The thing I wonder is, perhaps you have learnt this before.

20 E: I am wondering about the transition between the liver and the digestive system. Maybe, we can seek an explanation through examining this model.

In this example, the students' motivational engagement with the group task was challenged as a result of the lack of enthusiasm expressed by Brus, and subsequently controlled by Ezgi and Vural through a shared regulation process. In turns 8 to 14, Ezgi's utterances, eye contact and tone of voice showed her encouragement for the partners to stay focused on the task, which was evidence of a shared control process. This effort was later supported by Vural, who approached Ezgi's request positively, and started thinking about a possible question. As a result of this shared regulation, the group became successful in terms of keeping their willingness high in relation to carry out their group task.

Another example of a shared regulation process is illustrated in the following episode taken from the '*football match*' small group activity. Prior to this episode, while group A has engaged in shared metacognitive regulation in which they negotiated each other's perspectives of the events occurring around and inside a footballer's body, their discussion has been ineffective in terms of building a consensus on a shared understanding due to the contradictory ideas expressed by the group members (see Episode 4.7 in this chapter). In the first part of this episode, after Kutay asks his partners to move to the next inquiry question, Leman disagrees with him and attempts to revise what they have previously discussed (turns 1 to 2).

While taking notes in relation to their discussion, Kutay looks confused about a word written on Leman's notebook and asks if it is neural or digestive (turn 4). At this point, Leman replies to Kutay's question in an unkind way, while her tone of voice and gesture also suggest an expression of boredom (turn 5) and her reaction challenges the positive emotional atmosphere of the group. After this incident, Kutay attempts to defend the necessity of asking his question with a negative facial expression and tone of voice which indicates his awareness of a negative emotional experience (turns 6 & 8). Next, Leman points out how inappropriate Kutay's question is, as he must know that 'neural' is the word written on her notebook as they are currently working on the nervous system (turn 9). However, Kutay teases Leman by

claiming that she has mistakenly written ‘neural’ instead ‘reflex’ (turn 10). He also tries to provide a justification for his claim in response to Ayse’s question (turn 13).

(Prior to Episode 4.13)

- 1 K: Should we look at the next question?
- 2 L: No Kutay (*with a loud sound*). Now, we have talked about three types of events, neural, physical and mental.
- 3 All: (*continue to take notes*)

Episode 4.13a – Small group activity three (Group A)

- 4 K: But, um, what is this [word], neural or digestive? (*pointing at Leman’s notebook while looking confused*) {*In Turkish, “sindirir” means digestive and “sinirsel” means neural, so the initial letters of these words are the same and hence could be confused*}
- 5 L: Don’t be silly, Kutay! (*taking a deep breath while leaning back and forward and speaking in a bored tone of voice*)
- 6 K: Leman, I can’t read it! (*eyebrows are lowered and the volume of his voice rises while leaning back away from the desk*)
- 7 L: How can it be “digestive”? (*stares at Kutay*)
- 8 K: But it starts with an ‘S’, what else can it be? (*looks upset*)
- 9 L: Of course it is ‘neural’, we are working on the nervous system now (*speaking in a bored tone of voice*).
- 10 K: There is no such thing as neural, it is called reflex (*looks at both Leman and Ayse with a sad facial expression*).
- 11 L: (*looks at Ayse*)
- 12 Ay: Neural? Are we really going to say neural is reflex (*confused look*)?
- 13 K: Yes, you will write reflex. Look, Leman, when we think about neural events, we refer to the nervous system, but only reflex is involved here (*staring at Leman with a negative frowning expression and playing with his pen constantly*)

In the second half of this episode, the socioemotional challenge the group is facing also triggers another challenge within the group. That is, while staring at Kutay with a sad face, Leman reminds her partners that still none of them has a clear idea of the

correct answer and also points out the complexity of the inquiry question (turn 14). Next, Kutay stares at Leman with a negative facial expression and makes a critical comment about her perceived status within the group (turn 15). Then, both Leman and Kutay engage in an argument which leads to them deciding to study independently from each other (turns 16 to 19). At this point, Ayse reminds Leman that they are studying collaboratively as a group where they should acknowledge the significance of the ideas that each of them puts forward (turns 20 & 22). Ayse's reaction can be seen as a process of controlling the group's emotional and motivational states. After this, Kutay and Leman also try to explain how they value each other's ideas too, joining Ayse in controlling their negative emotions (turns 23 to 24). In the end, Leman attempts to encourage her group to engage in the task again, which slowly results in the restoration of a positive learning atmosphere in the group. Following this episode, group A carried on with their discussion, while Kutay showed less participation, but only for a short time.

Episode 4.13b – Small group activity three (Group A)

- 14 L: Kutay, at the moment, none of us know the correct answer, anyway
(*looks at K and speaks with a furious tone of voice*).
- 15 K: OK, Leman, humph! You are always the right one, anyway (*raises his shoulders while looking at his notebook and speaking in a low tone of voice*) (*glances at L*)
- 16 L: I want to do this way (*stares at K*).
- 17 K: OK, I want to do my own way too (*pointing at his notebook*).
- 18 L: So, don't interfere with me (*starts writing*).
- 19 K: OK (*looks very upset*).
- 20 Ay: Leman, but we are working as a group (*looks at L and speaks in a calm tone of voice*).
- 21 L: Ok, but didn't we agree on neural events at the beginning? (*speaks in a calm tone of voice*).
- 22 Ay: But Kutay is also talking about reflex too. I am writing his idea in parenthesis now (*writing K's suggestion on her notebook*).
- 23 K: I am writing it in parenthesis too (*speaks in a calm tone of voice*) (*writing*).

- 24 L: When I say neural events, I also think about reflex. That's why I have said so (*looking at K*).
- 25 L: (*After a few seconds of silence*) let's give an example for mental events too (*looking at Ay*).
- 26 Ay: Something like defending. Can we call it mental?
- 27 K + L: (*no response from either of them*)
- 28 L: Should we read the next question?
- 29 Ay: Yeah.

In their stimulated-recall group interview, the students were encouraged to reflect on what happened during this episode. When asked what they thought about this incident, Leman explained the reason as why she reacted to Kutay's question in a way which created a challenging situation for their group (turns 2 & 4). Kutay also explained how he attempted to control his motivational and emotional state individually. In his comments, he explained that he wanted to defend himself against Leman by disregarding the word 'neural', even though he actually acknowledged the correctness of this word (turns 6 & 8). Also, he explained that Leman's disagreement led him to comment negatively about how she was seen within the group, which then caused the emergence of another socioemotional challenge (turns 16 to 23). Furthermore, when Ayse was asked about why she reminded Leman about working as a group and valued Kutay's idea, she explained that she knew how the latter was feeling during this incident as she had also been on the receiving end of similar encounters with Leman previously (turns 25 to 29). In the last interview comment, Kutay also explained how he was feeling in response to Leman's reaction after he misread the word 'neural' and how good he felt as a result of Ayse's emotional support (turns 30 & 32).

Stimulated-recall interview 4.3 – Group A

- 1 I: So what happened here?
- 2 L: Kutay tried to read my notebook upside down, but he read 'neural' as 'digestive'. And then I said 'what you are saying', and then I began to defend myself.
- 3 Ay: No, you said "don't be silly Kutay!".
- 4 L: Yeah, but we were in the subject of nervous system.

- 5 I: For instance, Kutay, I am just wondering, when you said that there is nothing called neural, did you really believe that there was not something like neural or there was something else behind your response?
- 6 K: Of course it was a counter-attack (*laughing*). I mean there is of course something called neural.
- 7 I: Yes, can you explain this a little bit more?
- 8 K: There is something called neural actually. Certainly, I just told this, don't know why. It was against Leman to defend myself, I guess. I was looking at her notebook, but could not see very well because of her small handwriting.
- 9 L: Is it small?
- 10 K: Yes.
- 11 I: OK, the rest of your conversation is so funny. Let's look at it.
- 12 All: (*laughing and watching*)
- 13 I: Yes, what's happening here?
- 14 K: Me?
- 15 I: Yes, when you say that "you are right all the time".
- 16 K: I don't know. Leman knows everything perhaps that's why.
- 17 I: But, she may not know everything really.
- 18 L: Yeah.
- 19 K: But I thought that was the case.
- 20 I: Here, Leman.
- 21 K: Here, Leman did not support my idea, that's why I have said she was right all the time.
- 22 L: Yeah but you didn't intend to say it to praise me.
- 23 K: I was showing a bad attitude towards her and the reason for this was that she didn't support my idea,
- 24 I: So, why did you talk like that, Ayse?
- 25 Ay: Because, Leman sometimes, I really realise that sometimes she criticises Kutay's ideas in an insensitive manner.
- 26 K: Yes, she does.
- 27 Ay: Even though we always work together in other lessons, because I want that. But she sometimes does the same thing to me too, so I wanted to help Kutay here because I knew how he was feeling.

- 28 I: Also in order to maintain working as a group?
- 29 Ay: Yes.
- 30 K: Yes, she was really helpful.
- 31 I: Kutay here you seem a little bit upset, what were you feeling?
- 32 K: Of course, I was angry with her, because she rebuked me during this incident. I didn't really feel very good, but Ayse supported me, this was good. But Eventually, Leman was proved right and this made me also feel sad.

As the analysis reveals, in this episode the students became aware of their negative emotional experiences and attempted to control their emotional and motivational states individually as well as socially, which then became successful in terms of maintaining their shared motivational engagement while working collaboratively. For instance, Kutay's utterances, facial expressions, voice tone and gestures indicated awareness of a negative socioemotional experience which challenged his own as well as the group's motivational engagement. In addition, all the group's utterances, eye contacts and voice tone showed evidence of controlling their group's emotional and motivational states by means of emphasising a sense of tolerance and togetherness as well as valuing and encouraging respect for each other's feelings and ideas. Also, the stimulated-recall interview was successful in terms of revealing how and why the negative emotional experiences emerged as a result of the students' reciprocal interactions, and how and what they felt about them as well as the ways in which they attempted to socially regulate them in order to maintain their level of motivated engagement with the group work high.

4.5 Relations between types and forms of regulation processes

As explained in Chapter 2, as the previous research has usually focused on investigating metacognitive, motivational and emotional aspects of student's learning separately, from an individualistic perspective, there is limited understanding of how different types of self and social forms of regulation processes may influence and interact with each other. In addressing this gap in the literature, this section scrutinises some of the sequences of regulation episodes with the aim of exploring if and how self and social forms of metacognitive, motivational and emotional regulation processes may be related to one another. The Figures 4.7, 4.8, 4.9 and 4.10

illustrate the sequences of the episodes, some of which have already been discussed in the previous sections and in Chapter 6 (see Appendix F for the transcriptions of episodes in the Figures 4.7, 4.8 and 4.9).

As the figures below show, the analysis suggests that the student engaged in different types of regulation processes over time, which each had different foci and functions, during small group scientific inquiry activities. For instance, as Figure 4.7 taken from the third small group activity illustrates, after Kutay engages in self-regulatory metacognitive monitoring process in turn 63 in which he makes an assessment of his own understanding, group A utilises a shared planning process in turns 70 and 71 in which Kutay and Leman suggest moving to the next inquiry question. Next, while attempting to answer this question, a co-regulatory metacognitive monitoring process (turns 75 to 86) emerges among Kutay, Leman and Mrs. Celin in which Kutay becomes aware of his misunderstanding of the topic. Following this, in turns 85 to 87, Kutay expresses awareness of a negative emotional experience and attempts to control his emotional and motivational states individually. Then, all three members of group A engage in a shared monitoring process in turns 88 to 96 where they negotiates their mutual understanding of the topic.

This analysis also suggests several types of interplay among self, co and shared regulation of metacognitive, motivational and emotional processes during small group activities. Firstly, a relationship has been identified between self and social forms of emotional and motivational regulation processes. In particular, in some instances, the student groups used shared control processes after an individual group member engaged in emotional and motivational self-regulation process. Episode 4.14 described in Section 4.3.3 presents evidence of this type of interplay (see turns 37 to 60 in Figure 4.7). As explained in detail in this episode, after expressing a negative emotional experience emerging through his interaction with Leman, Kutay attempted to control his own emotional and motivational state. However, his individual regulatory attempt triggered the emergence of another negative emotional experience for his group, which then led to group A controlling their emotional and motivational states collectively. Similarly, as described in Episode 4.12, Brus's expression of a lack of enthusiasm, which indicates an individual monitoring process, led to his peers taking responsibility for their shared emotional and motivational states.

Figure 10 taken from the ‘water content of our body’ small group activity also presents another example for interplay between self and social forms of emotional and motivational regulation processes. During this activity, while group B tries to answer the inquiry questions, Brus expresses a negative emotional experience as a result of his interaction with Vural in turns 26 to 30, 38, 57, and 61 as well as attempts to control his own emotional state (turns 67 to 72) which then becomes unsuccessful and challenges the positive atmosphere of the group, leading Brus to momentarily disengage from the group task. Next, Ezgi initiates a shared motivational and emotional control process that helps Vural and Brus engage again with the group task.

Moreover, the analysis shows some evidence of interplay between the occurrence of metacognitive and motivational and emotional regulation processes. In some cases, the processes of metacognitive regulation occurred concurrently with and appeared to influence motivational and emotional regulation processes. An overlap can be identified between these two types of regulation episodes as shown in each of the figures illustrated below. For instance, the following episode (from the ‘poisonous plant’ small group activity) occurring between turns 32 to 39 in Figure 4.9 presents this kind of relationship. Prior to this episode, the group A has been sharing and discussing ideas about how the reflex occurs when the child pulls his hand away after touching the poisonous plant. In this part, while the group is revising their mutual understanding through engaging in a shared metacognitive evaluation (turns 31 to 39), Mrs. Celin praises them for their discussion, which indicates a co-regulatory motivational and emotional control process (turns 34 & 38). That is, in this example, these two regulation types occur simultaneously, whereby the shared evaluation episode used by group A appeared to initiate the episode of motivational co-regulation with the teacher.

(Prior to Episode 4.15)

28 Ay: Should we draw this? (*pointing at the model*)

29 L + K: (*nodding*)

30 T: (*approaches to the group A and starts listening to group discussion*)

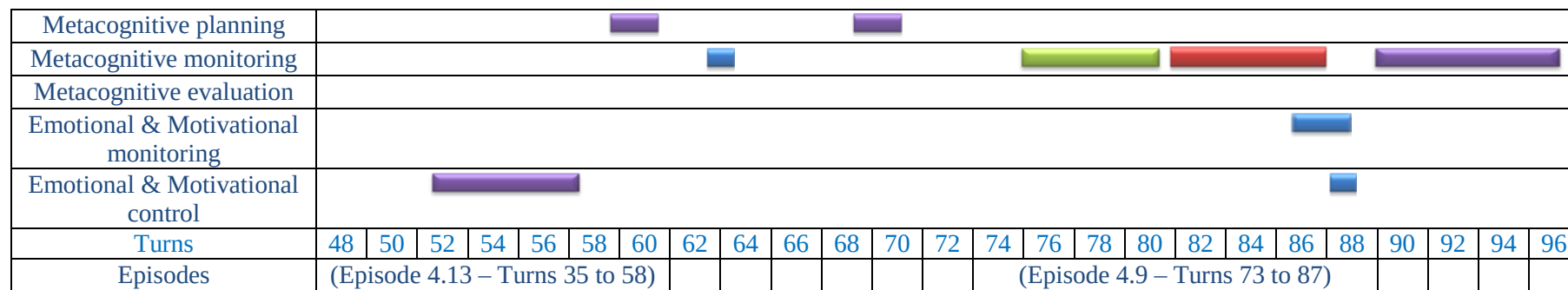
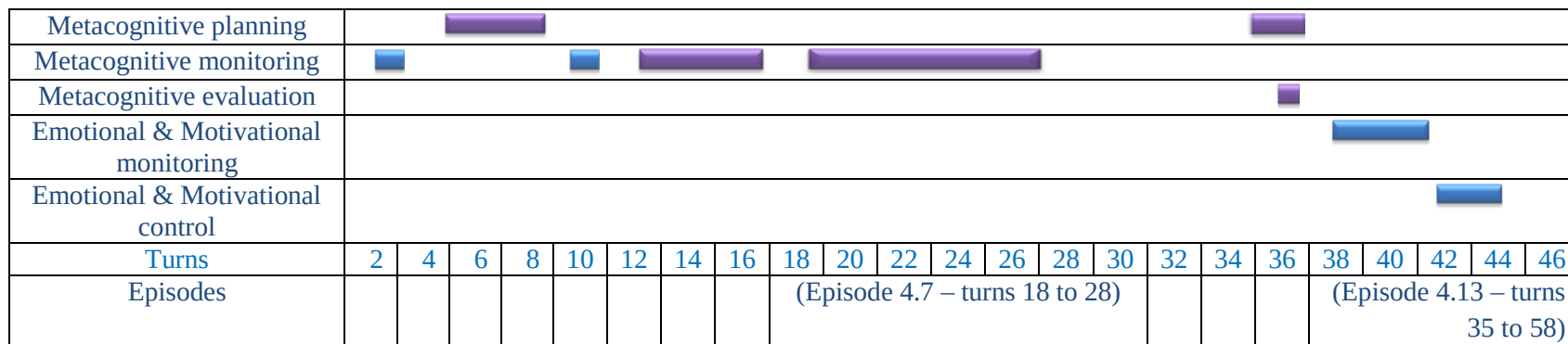
Episode 4.15 - Small group activity four (Group A)

31 K: So eventually we say, first of all the acid contacts the neurons (*glances at the teacher and points at the nervous system diagram*).

- 32 L: It goes to the spinal cord (*looking at the diagram*).
- 33 K: and the neuron reaches to the spinal cord, the spinal cord decides on the response and sends it back.
- 34 T: Yes, wonderful, this is the most noticeable event in this activity.
- 35 L: The reflex is formed and he pulls his hand away.
- 36 Ay: Pulls immediately.
- 37 L: In other words, the signal doesn't go to the brain (*glances at teacher*).
- 38 T: Brilliant, well done! You can explain it in this way. You don't have to draw it on the nervous system model (*she leaves the group*).
- 39 All: (*all start writing*)

Episode 4.9 illustrated in Section 4.3.1 also presents another example for this type of interplay (see turns 73 to 87 in Figure 4.7). As explained in detail, after engaging in co-regulatory monitoring with Leman and Mrs. Celin, Kutay simultaneously expressed awareness of a negative emotional experience and attempted to control his emotional and motivational states individually. This example also provides evidence of interplay between metacognitive and emotional and motivational regulation, since the negative emotion experienced by Kutay appears to emerge as a result of a metacognitive co-regulation process with his teacher.

Figure 4.7 – Group A - small group activity three (Minutes 11.15 – 19.20)



 Self-regulation
  Co-regulation with teacher
  Co-regulation among students
  Shared regulation

Figure 4.8 – Group B – small group activity four (Minutes 21.15 – 26.00)

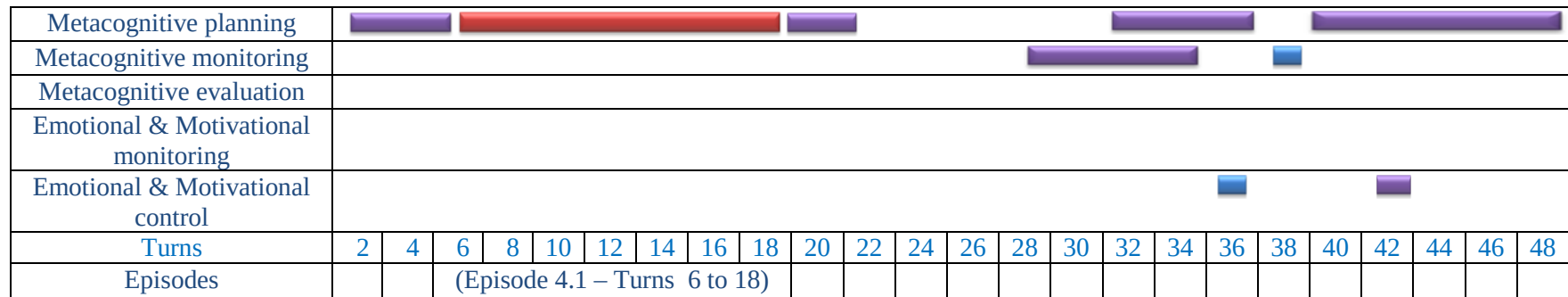
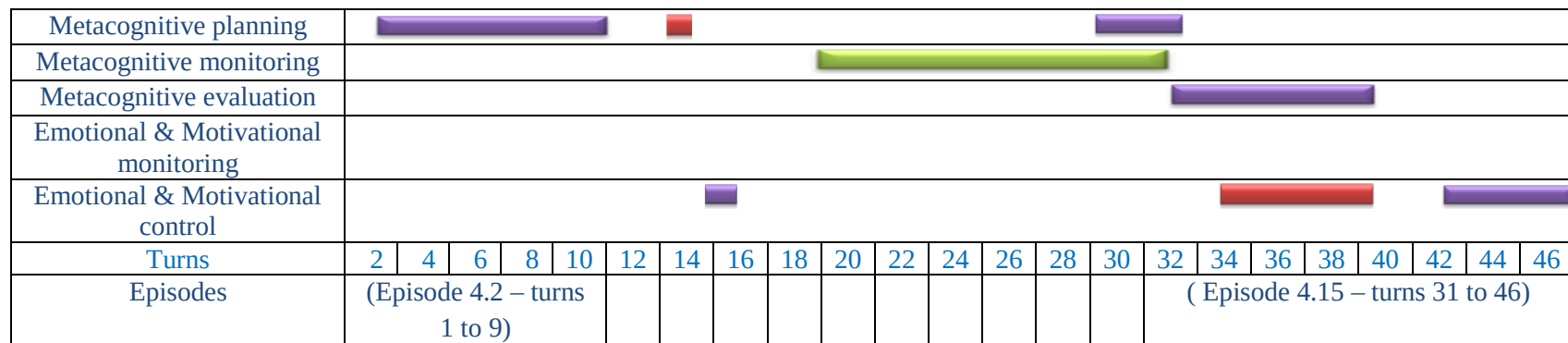
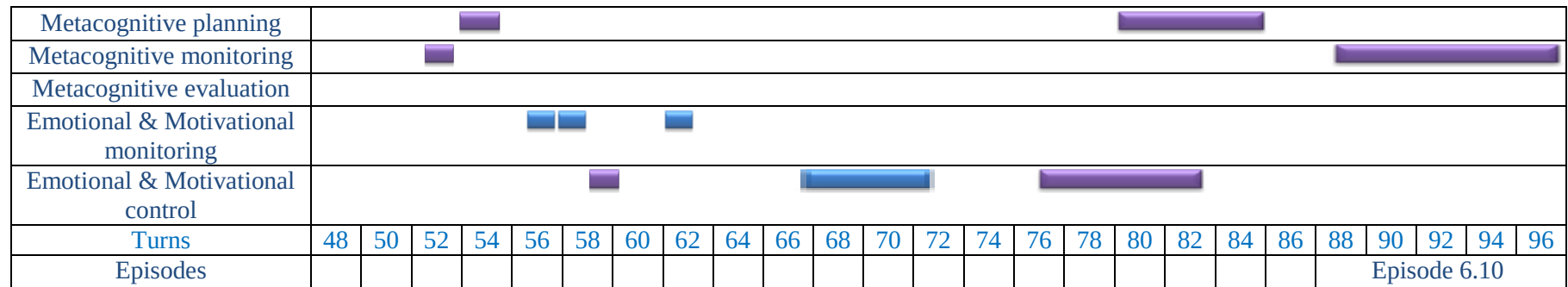
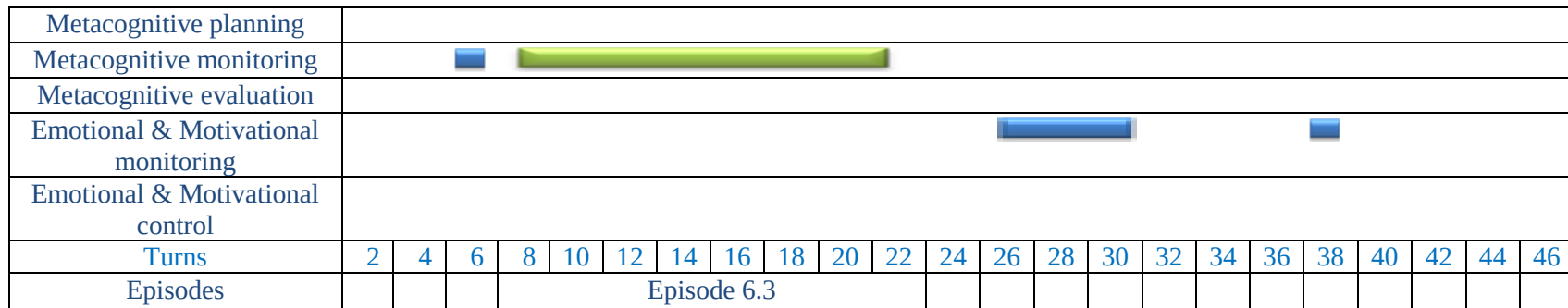


Figure 4.9 – Group A - small group activity four (Minutes 23.30 – 27.20)



Self-regulation
 Co-regulation with teacher
 Co-regulation among students
 Shared regulation

Figure 4.10 – Group B - small group activity five (Minutes 14.00 - 22.45)



 Self-regulation
  Co-regulation with teacher
  Co-regulation among students
  Shared regulation

4.6 Chapter summary

The results have shown substantial evidence of episodes of self-, co-, and shared regulation of learning that the upper primary students (aged 12) engaged in while learning about human body systems during scientific inquiry learning activities. All these forms of regulation processes showed differences in relation to which regulation phases they occurred in and what aspects of the students' learning they focused upon.

In episodes indicative of metacognitive self-regulation, the students showed individual regulation of cognitive processing without any intention of influencing other students' learning. Moreover, during this form of regulation, while they engaged in monitoring processes, there was no evidence of planning and evaluation processes being identified in the analyses of the video and stimulated-recall interview data. As previous research suggests (Perry *et al.*, 2002; Veenman *et al.*, 2006; Whitebread *et al.*, 2009), this finding can be attributed to the difficulty of assessing some aspects of individual metacognitive processes, which are often implicit and impossible to observe by researchers. In sum, in the current analysis the self-regulatory monitoring processes focused on individual student's understanding of the content or actual performance of the task.

In co-regulation episodes, the students and the teacher engaged in metacognitive regulation processes while assisting and guiding another student(s) in his/her learning during a variety of brief asymmetrical forms of interactions. However, regarding this form of regulation, this was only evident during planning and monitoring processes. Co-regulatory planning forms focused on the understanding of the goals or the procedural aspects of the task, while the focus of monitoring processes was mostly on student understanding of the task content. The analysis of the interpersonal interactions in these episodes showed that students (and the teacher) always had a shared understanding of the task, and were able to sense and respond to ongoing changes in each other's thinking through questions, prompts and explanations.

In episodes indicative of shared metacognitive regulation, the students collectively regulated the group's cognitive processes towards a shared goal via reciprocal interactions. More specifically regarding this form of regulation, they showed evidence of their engaging in processes of planning, monitoring and evaluation by making their thinking visible, taking into consideration each other's perspectives, as well as being open to negotiating mutual understanding via elaboration, justification and questioning. In shared planning episodes, the groups set shared goals, clarified conditions about the shared task, negotiated or assigned roles within their group, or decided on how to proceed. These planning processes played an important role in building a shared understanding of the task among the group members, which appeared to facilitate the subsequent regulation processes. Whilst the shared planning processes focused on the understanding of shared goals or the procedural aspects of a group task, the focus of monitoring processes was usually on a group's understanding of the content or actual task performance, as discussed next.

Incidents of shared monitoring were observed when the students checked, assessed or made a judgement of their group's conceptual understanding or monitored the actual joint progress being made towards achieving a shared goal. While the shared monitoring processes mostly played a key role in fostering and facilitating mutual conceptual understanding, in a few instances these processes appeared to slow down the ongoing group discussion. Also in this analysis, it was elicited that there were a few instances of shared evaluation episodes, but these were only engaged in by the members of group A. In this type of episode, the students attempted to review their overall learning during the small group activities. The reason for few evaluation processes being observed could be because of the limited amount of time the students had during the small group activities, as most of the time they were not able to complete the tasks on time and hence find enough time to evaluate and reflect on their answers and progress.

The findings also revealed that the students' engagement in the scientific inquiry tasks was challenged at times by their emotional and motivational experiences, and that they were able to maintain their motivation through utilising self-, co-, and shared emotional and motivational regulation processes during small group and whole class scientific inquiry activities. Besides engaging in monitoring and/or

control of his/her emotional and motivational states individually, in co-regulation episodes, a student usually received assistance from the teacher in controlling his/her emotional and motivational state so as to maintain engagement with the task. Concerning shared regulation, after expressing or realising a positive or negative emotional and motivational experience or reaction, the students attempted to control shared emotional and motivational states collectively via reciprocal interactions. All these regulation processes were focused on either the socioemotional aspects of their learning or motivation regarding the learning task.

Furthermore, the results provide some evidence about the relationship between different types of metacognitive and motivational and emotional regulation processes. Firstly, the students engaged in multiple forms and phases of metacognitive regulation processes during small group activities, whereby they continually focused on regulating different aspects of their learning, switching between symmetrical and asymmetrical forms of interactions. Also, the analysis elicited interplay between self and social forms of emotional and motivational regulation processes. That is, in some instances shared emotional and motivational control processes occurred as a result of a self-regulatory monitoring and/or control process. Lastly, the findings revealed an overlap between metacognitive and emotional and motivational regulation episodes. For instance, as shown in Section 4.5, in some cases, the processes of metacognitive regulation occurred concurrently with and appeared to influence the emergence of motivational and emotional regulation processes.

Chapter 5 – Changes in Regulation of Learning across Scientific Inquiry Activities

5.1 Introduction

After looking at the evidence of self-, co-, and shared regulation processes engaged in by students during scientific inquiry activities, in addressing the second research question, this chapter examines how students' regulation of learning processes change over time across the sequence of whole class and small group scientific inquiry activities. The empirical data analysed in this chapter consist of video recordings of the case students and teacher during introductory activities, whole class discussions and small group activities, audio recordings of the stimulated-recall and semi-structured interviews with the student groups A and B, informal interviews with the teacher and the field notes collected during the lesson observations. As described in the previous chapter, the video and stimulated-recall interview data were analysed in order to identify self and social forms of regulation processes. All forms of regulation processes were classified if they were occurring in an introductory activity, small group activity or whole class discussion, as well as if they were occurring only among students or between the students and the teacher. In addition, each regulation episode identified during the small group activities was classified in terms of the involvement and contribution of each member of groups A and B.

Moreover, the semi-structured interviews with the student groups, the informal interviews with the teacher and the field notes were analysed qualitatively in order to elicit the objectives and characteristics of each activity as well as the profiles of the student groups, all of which provided background information for the interpretation of the findings. Similar to Chapter 4, all the statistical data are presented in terms of rates, which denote the frequency of episodes occurring in each ten minutes of the learning activities (see Appendix B for the sequence and duration of activities).

In this chapter, firstly I will examine the rates of regulation episodes over time across the whole class and small group activities by taking into account the characteristics and objectives of each activity type. Then, I will address the regulation of learning processes over time for the student groups by considering the group profiles.

5.2 Introductory activities

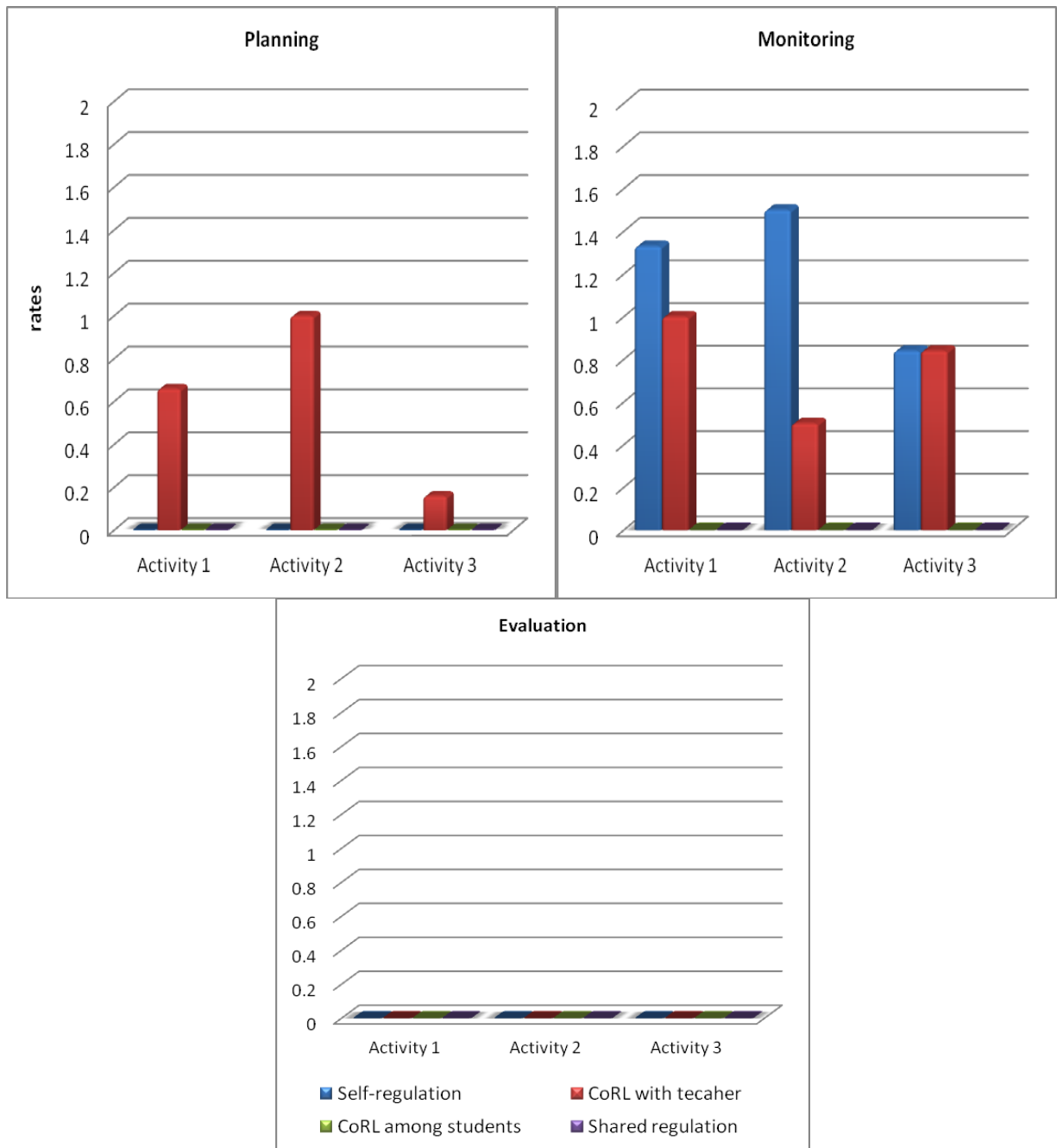
The introductory activities took place at the beginning of each of the scientific inquiry topics: the digestive system, the nervous system and the excretory system. During these activities, in line with the aims mentioned previously, Mrs. Celin probed students' preconceptions through offering them opportunities to articulate their ideas and questions, as well as endeavouring to create interest and curiosity among the students in relation to the science topic being introduced (see Appendix G for a typical dialogue that exemplifies these pedagogical interactions occurring during the introductory activities).

Figure 5.1 presents the rates of categories of self-, co-, and shared metacognitive regulation processes across three introductory sessions. As can be seen in this figure, co-regulation processes with the teacher were mostly prevalent during these activities. For example, in terms of planning processes, the students only engaged in co-regulation episodes with their teacher, showing no sign of the other regulation types. This can be explained due to the nature of introductory activities, whereby the students did not need to make any individual or shared planning at the beginning of each science topic. Instead, as explained in Subsection 4.2.1, the teacher played an important role in planning their learning, through supporting them in setting learning goals, activating their prior knowledge, and clarifying the purpose of the task at hand.

Turning to the monitoring category, the students showed evidence of self-regulation and co-regulation processes with their teacher, but there was no sign of shared regulation or co-regulation processes with their peers in this regard. This result can be attributed to the fact that students were asked to think more about their individual understanding of the topic, and did not have a chance of engaging in reciprocal

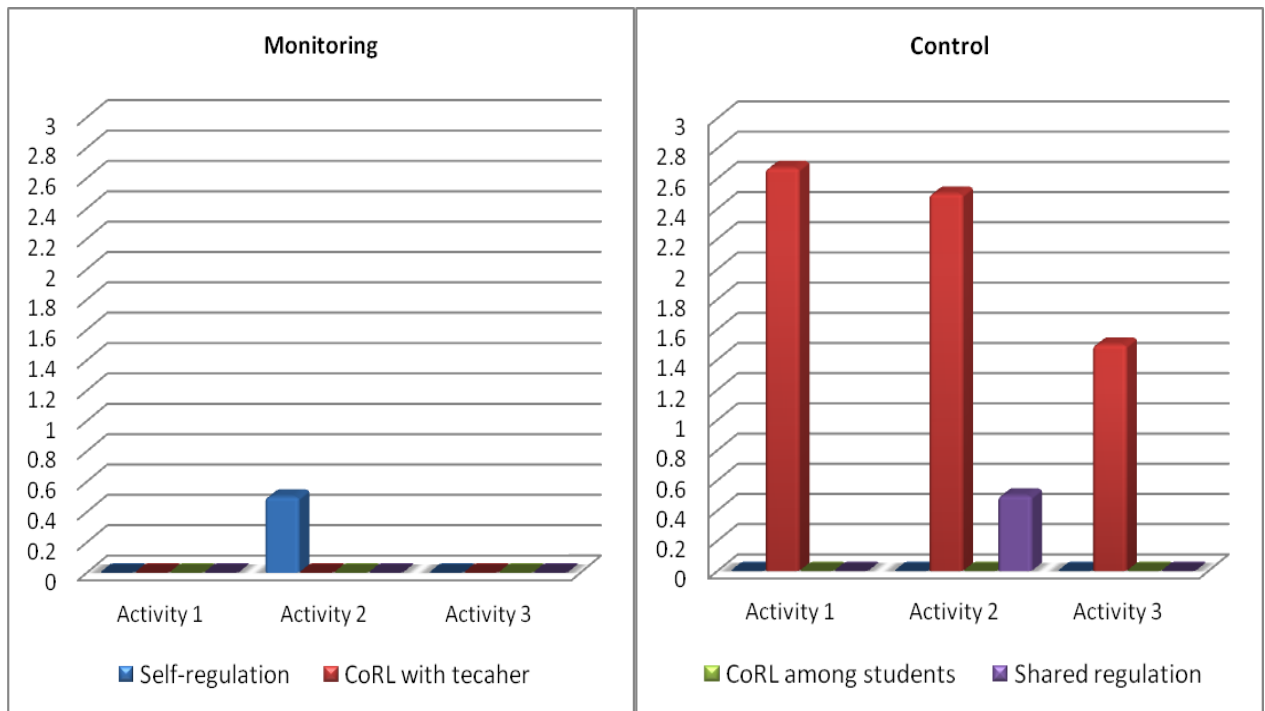
interactions among each other, as they mostly interacted with the teacher. Lastly, for the evaluation category, no evidence of any form of regulation was identified during the introductory activities.

Figure 5.1 – Rates per session of the episodes of metacognitive planning, monitoring and evaluation across the introductory activities



When looking at the changes in the students' use of metacognitive regulation processes, as shown in Figure 5.1, the rates of regulation episodes fluctuated over time. That is, while the rates of individual monitoring and co-regulatory planning episodes with the teacher showed an increase in the second session, there was a sudden decrease for both types of regulation during the last activity. Moreover, the rate of co-regulatory monitoring episodes decreased in the second activity, whereas there was an increase during the last introductory session.

Figure 5.2 – Rates per session of the episodes of emotional and motivational monitoring and control across the introductory activities



Concerning the emotional and motivational regulation episodes, Figure 5.2 also illustrates notable patterns. As can be seen, in terms of these forms of monitoring processes, only self-regulation episodes were identified during the second activity. In terms of control processes, co-regulation episodes with the teacher were prevalent across the three introductory sessions, while the students also showed evidence of a shared control process, but only during the second activity and with a lower rate. This result is not surprising when considering the characteristics of the introductory activities, which were almost entirely centred on the teacher's goal of enhancing the

students' interest and engagement with the new science topics. As mentioned in Subsection 4.3.2, co-regulatory control processes with the teacher usually promoted students' active engagement with the learning task and contributed positively to the socioemotional atmosphere of the classroom. These control processes slightly decreased over time across the introductory activity sessions.

5.3 Whole class discussions

Whole class discussions always took place after each small group activity in order to present students with opportunities to explain and reflect on their ideas and answers. In these discussions, Mrs. Celin encouraged them to communicate and negotiate their individual and shared ideas with the class as well as to extend their understanding of the science topics being studied. She regularly incorporated students' ideas into the flow of classroom discussion, showing them that she was interested in their perceptions and valued hearing their voices. Moreover, unlike for the introductory activities, she very often challenged their thinking, expecting them to reflect on, clarify or justify the ideas they shared. In response, the students almost invariably appeared to be comfortable in accepting these challenges and most of the time provided protracted answers as well as being able to build or comment freely on the viewpoints of their peers. Throughout the discussions, Mrs. Celin used a non-judgemental tone and often sought agreement with the students concerning the ideas put forward (see Appendix H for a typical dialogue which exemplifies these pedagogical interactions occurring during the whole class discussions).

Figure 5.3 illustrates the rates of the categories of self-, co-, and shared metacognitive regulation episodes across the whole class discussion sessions. The analysis of this figure reveals noteworthy patterns which can be explained by considering the characteristics of these sessions. In terms of the regulation processes, whole class discussions invariably included asymmetrical interactions occurring between the teacher and students. That is, similar to the introductory activities, co-regulatory planning and monitoring processes with the teacher were mostly prevalent. However, the rates of these co-regulatory monitoring episodes were almost twice as high as the rates observed during the introductory activities. This can

be attributed to the fact that as these discussions mostly took place after small group activities, the students were more willing to share and discuss their ideas, and hence the teacher was more able to monitor students' understanding and progress than were it otherwise. Although, the students often shared and discussed their group's ideas with the class, no evidence was found of shared regulation processes during the whole class discussion sessions. Furthermore, akin to the introductory activities, no evidence of evaluation was identified, which can be attributed to Mrs. Celin's use of a non-judgemental approach, whereby she avoided evaluative comments on the students' ideas and questions.

With regards to changes in the students' use of metacognitive regulation episodes over time, similar to during the introductory activities, the rates of co-regulatory planning and monitoring processes with the teacher fluctuated across the whole class sessions. Moreover, there was a considerable increase in the rates of individual monitoring processes in the second session, followed by a sudden decrease in the third, with this aspect remaining at a similar rate for the remaining two sessions.

In terms of emotional and motivational regulation episodes during the whole group discussions, Figure 5.4 also shows some notable patterns. For instance, while there was no sign of shared or co-regulation processes among the students, episodes of emotional and motivational control processes with the teacher were a common feature. Also, as was the case during the introductory activities, the rate of these control processes with the teacher showed fluctuations over time across the sessions. Moreover, the students showed evidence of individual monitoring processes only in the last two sessions and engaged in control processes only during the fourth discussion session.

Figure 5.3 – Rates per session of the episodes of metacognitive planning, monitoring and evaluation across the whole class discussions

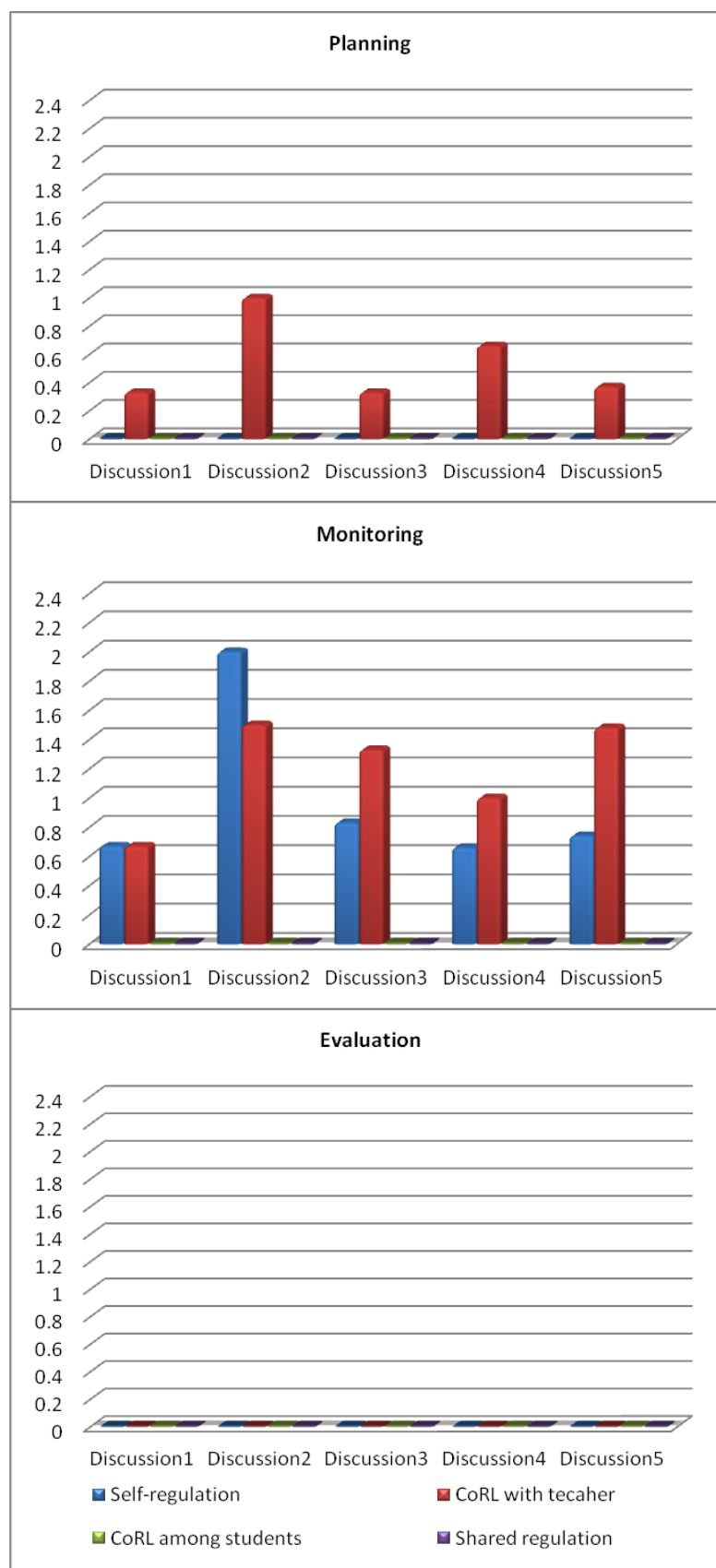
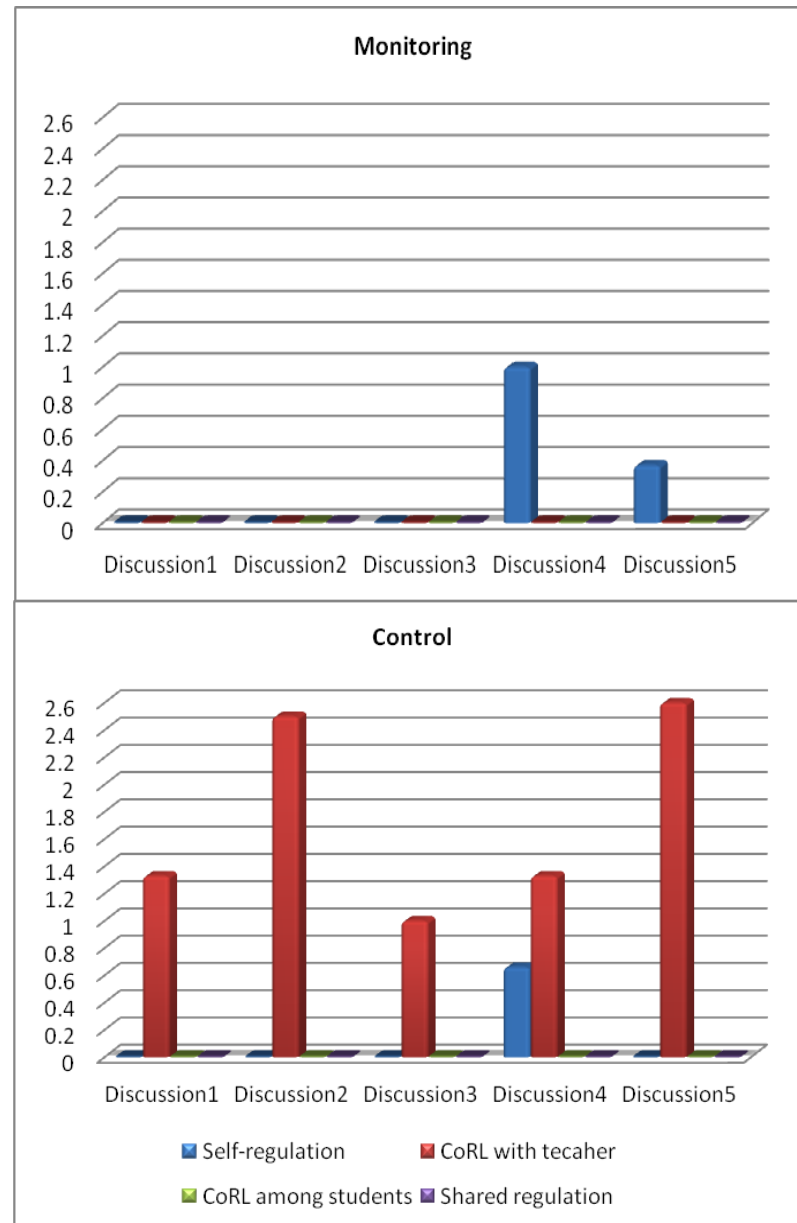


Figure 5.4 – Rates per session of the episodes of emotional and motivational monitoring and control across the whole class discussions



5.4 Small group activities

After each introduction session, the students engaged in small group activities in which they carried out observations and investigated a set of inquiry questions collaboratively in relation to the topics of digestive system, nervous system and excretory system, as explained in Chapter 4. As Mrs. Celin stated during one informal discussion, the group tasks were all linked to students' daily lives, thereby

presenting opportunities for them to make a connection between the inquiry science topic and their shared experiences. These group tasks were also designed to encourage them to seek more than one answer or idea as well as becoming progressively more difficult and challenging over time towards the end of the inquiry science unit. For example, the first three small group tasks were classified by Mrs. Celin as moderately difficult and the last two as difficult including more open-ended questions and requiring more complex reasoning from students (see Appendix C for the group task worksheets).

At the beginning of each small group work session, Mrs. Celin provided the students with both written and verbal instructions about the objectives and rules of these activities. She invariably emphasised shared responsibility and active participation of all the students for the effective collaboration, as the following excerpts illustrate.

Episode 5.1 – Small group activity 1

T: OK, Listen to me. Now, groups, you will discuss ideas for the inquiry questions together. But I don't want you to just read or ask each other what you have found. I don't want this. Now, you have learnt a lot of things, when you answer these questions, I want you to discuss the information you have with each other. Rather than only telling each other what you have written blah, blah, I want you to explain and discuss your ideas effectively so that you can benefit from this group work... In order not to be influenced by each other, I want all groups to sit separately, one table for each group. Let's do this without causing chaos. This group can sit at that table (*showing each group an appropriate place to work*). Who is sitting at this table?

M: Our group.

T: OK, please come here now... Please listen to me! During the group discussion, I don't want to hear any loud noise, so please speak quietly. You must be able to hear your group members. As I said, you are not just reading your answers, but also discussing how correct they are. Try to figure out which idea is the most correct one. At the end of this lesson, each group will

hand in its answers to me on only one paper, not individually. When I move around, I will provide support when you need, but don't expect me to give you the answers, because I won't tell you anything, but only provide just a little help, because I want you to reach the correct answer within your group.

Episode 5.2 – Small group activity 5

T: Alright, you will do another activity with your groups now. After my explanation, some of the groups can go to the back of the classroom, if you like. This is a very important activity which I care a lot about. Now, I will give you the question papers which include some graphics and pictures. There is a hormone and an endocrine gland which you have never heard about: the hypothalamus and the ADH hormone. There is a short note about these concepts and a few important points on the pictures... I would like you to answer these four questions as a group together, after you understand what these graphs and diagrams mean. The third and fourth questions are about what you have learnt about this topic. But the first and second questions are related to how you interpret these graphics and pictures. Therefore, this is very important for me. First of all, you will understand these diagrams as a group and attempt to answer these questions. Is that clear?

All: Yes.

T: Please, don't forget to write your group names on your answer sheet and you will hand it in to me after you have discussed these questions. Now, it is so important for me that you are discussing with each other. You will not get any marks for this activity, but I want to see your skills.

For the small group activities, the students carried out observations through watching video clips on the interactive whiteboard as a class and/or examined diagrams and other resources, and subsequently engaged in collaborative discussions within their group. During these discussions, they shared their observations and viewpoints, made joint decisions on the procedural aspect of the

group work, and negotiated and sought consensus regarding their understanding. As will be covered in detail in the next chapter, they were helpful and supportive of one another, taking into account each other's perspectives, and being open to negotiating their mutual understanding. During the group work, Mrs. Celin visited each of the groups and when necessary provided help and often praised those who were actively performing their tasks (see Appendix F for typical dialogues occurring during the small group activities).

5.4.1 Changes in regulation of learning across groups A and B

Figure 5.5 shows the rates of the categories of self-, co-, and shared metacognitive regulation episodes engaged in by the student groups A and B across the small group activities. In terms of the planning category, the students in both groups mostly engaged in shared planning processes, and there was no self-regulatory or co-regulatory planning episode observed among students. This result can be explained by considering the characteristics of the small group activities. That is, as the students were instructed to work collectively towards a goal, they needed more shared than individual planning to carry out these activities (see Subsection 4.2.1 for a description of a shared planning episode). Also, the absence of co-regulatory planning processes among the students provides evidence that there was more equal participation within the groups in relation to the planning of their joint activities. In terms of the monitoring category, the students in both groups mostly engaged in individual and shared monitoring episodes (see Subsection 4.3.2 and Sections 6.3 and 6.4 for examples of metacognitive monitoring processes). Furthermore, unlike for whole class activities, there were instances of co-regulatory monitoring episodes among the students. Episodes of co-regulatory monitoring with the teacher were also identified for both student groups, but with lower rates when compared to the whole class activities. Regarding shared evaluation episodes, group A engaged in a few of these, whereas no clear evidence of these was identified for group B. This lack of shared evaluation, as explained in Chapter 4, was probably due to the limited amount of time allocated for the students to complete their group work activities.

While somewhat similar patterns emerged for groups A and B, when looking at the rates of regulation episodes over time across the group activities, slightly different ones were identified for both groups in terms of changes in the use of regulation processes across the different activities. For example, in terms of self-regulatory monitoring processes, while the rates fluctuated and overall exhibited a slight increase for group B, there was a considerable upward trend for group A over time across the small group activities. Moreover, for both of the groups, while the rates of shared planning episodes increased gradually during the first three activities, there was a sudden marked increase in the fourth group activity. However, for the last activity this rate fell sharply for group A and also showed a slight decrease for the group B.

In addition, in the last two activities, group B was observed to engage in more shared planning processes than group A. In terms of the monitoring category, the rates of shared monitoring episodes experienced a constant increase for both groups across the first four group tasks. However, as was the case for the shared planning episodes, this decreased suddenly for group A and slightly for group B when the last activity was tackled. Also, as explained earlier, only group A showed evidence of shared evaluation episodes only during the second and third activity, but with lower rates when compared to the other regulation processes. This increasing use of shared metacognitive regulation processes in which the students interacted in a more mutual and symmetrical way can be associated with the difficulty level of the group tasks, which progressively became more difficult towards the end of the scientific inquiry unit, such as through including more open-ended questions and seeking more complex explanations from the students. This perspective is supported by the previous research which has elicited evidence that metacognitive processes tend to emerge more frequently in appropriately challenging learning tasks than easy or extremely difficult ones (Iiskala et al. 2011; Vauras et al., 2003). In addition, the instruction of 'ground rules' by the teacher could be another reason for this increase, as it may potentially support more symmetrical and reciprocal collaborative interactions among the group members. This outcome could also be attributed to the increasing familiarity and mutual trust within the groups and between them and their teacher over time.

Figure 5.5 – Rates per session of the episodes of metacognitive planning, monitoring and evaluation across the small group activities

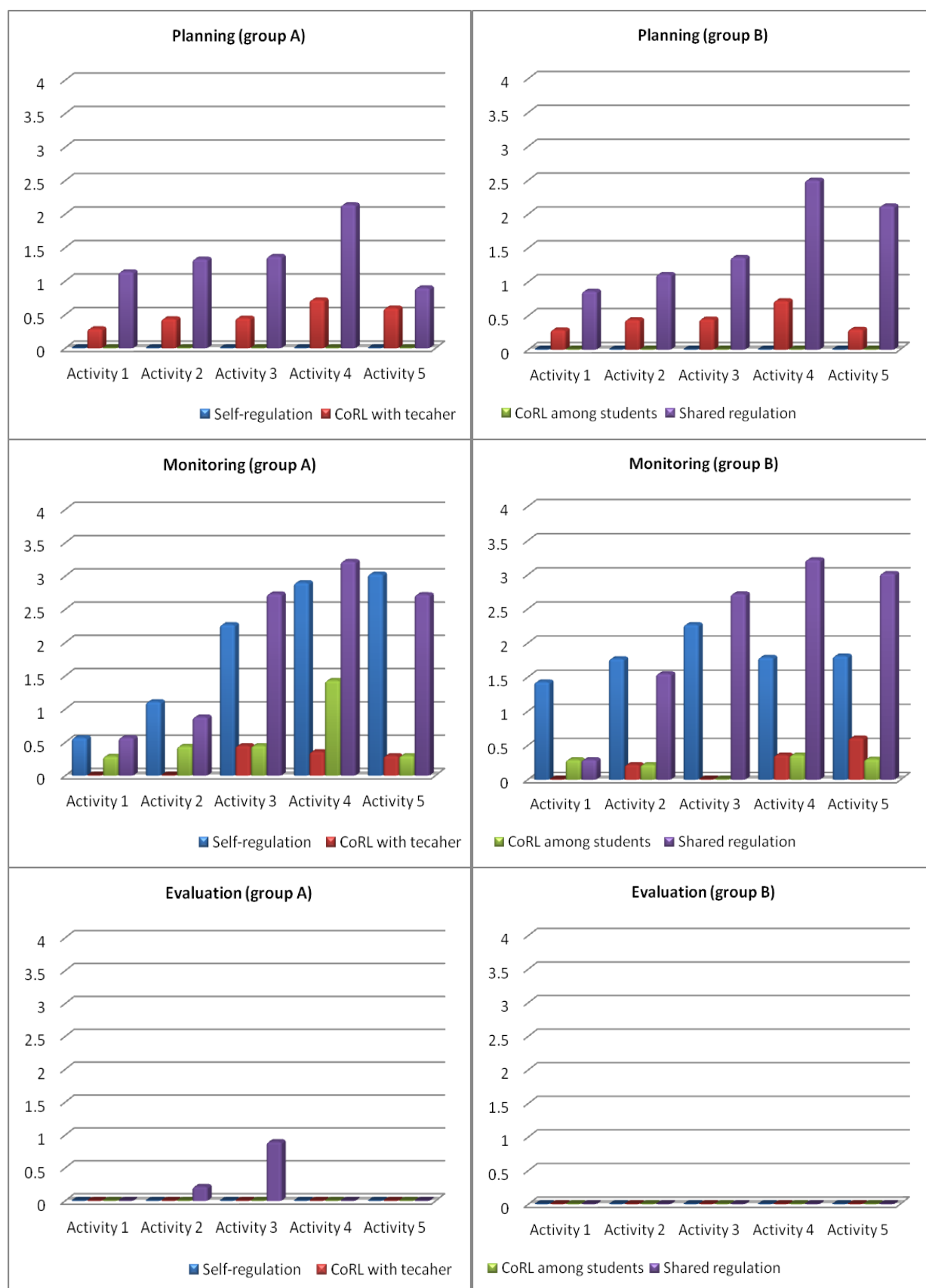
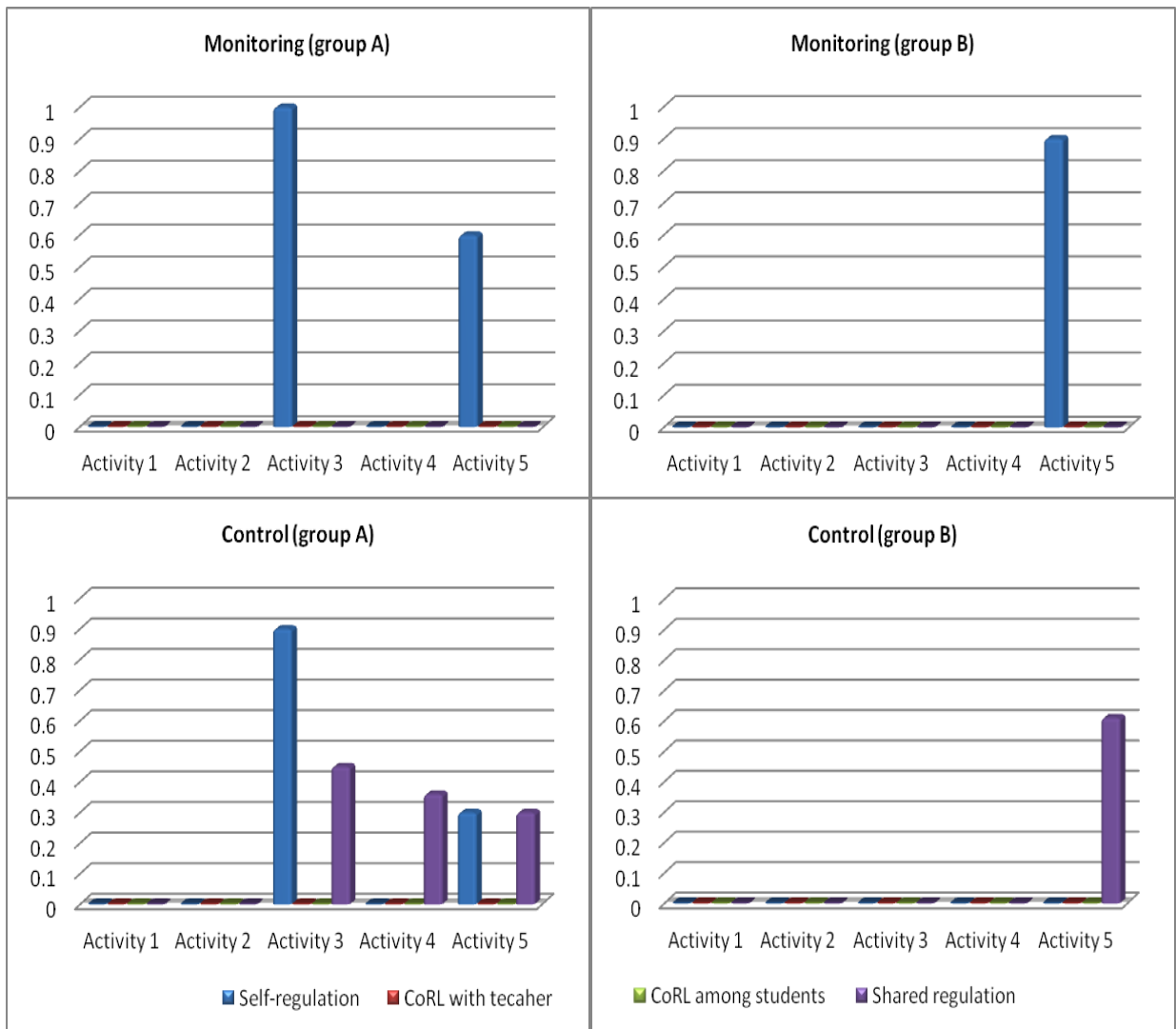


Figure 5.6 – Rates per session of the episodes of monitoring and control processes focusing on the socioemotional aspect across the small group activities

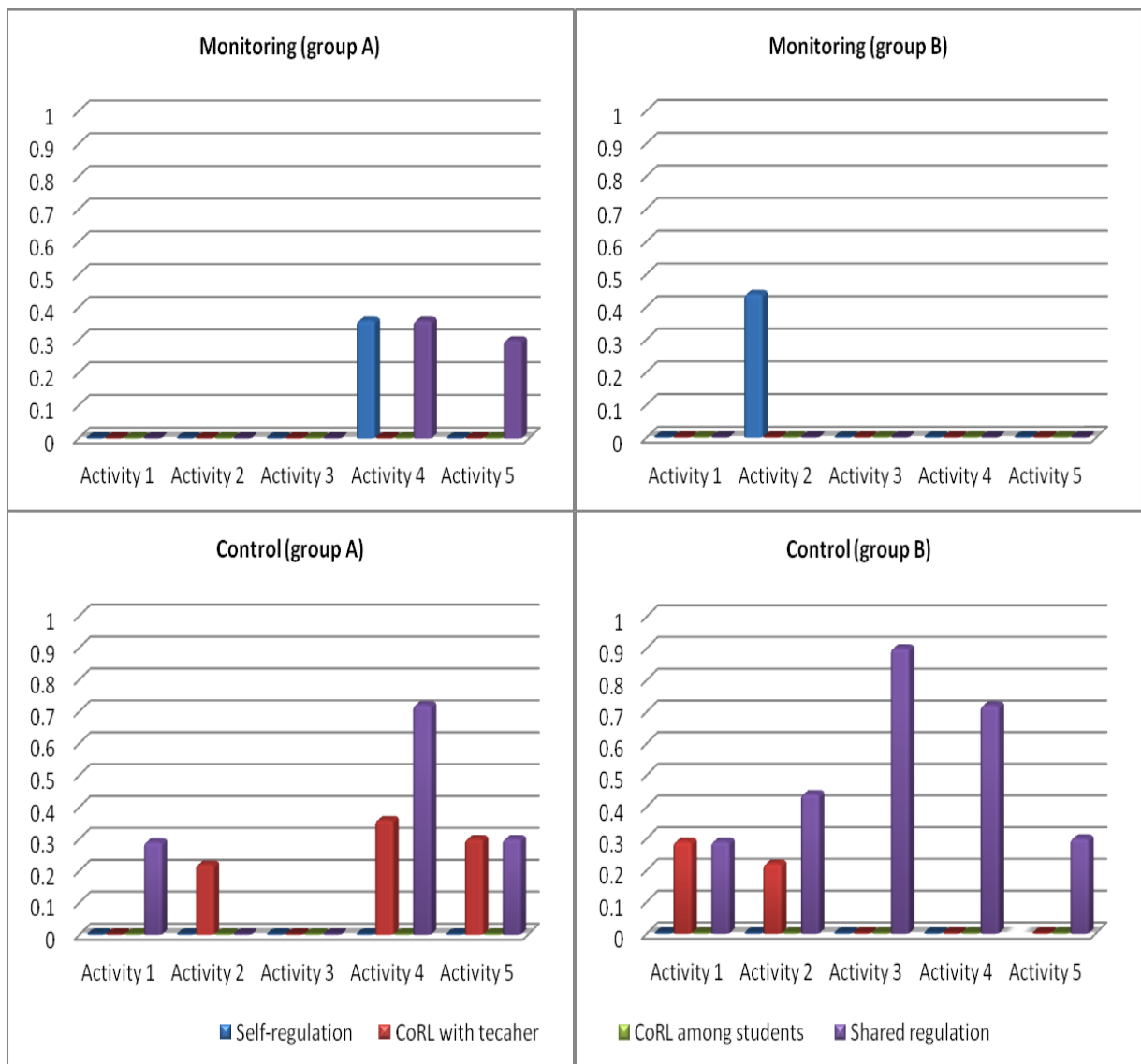


In comparison with the whole class activities, co-regulatory planning and monitoring with the teacher had lower rates for both groups A and B. With regards to the former, it engaged in co-regulatory monitoring processes with the teacher only in the last three group tasks, whilst the latter showed evidence of this during the second, fourth and fifth group activities. For both groups, the rates of co-regulatory planning episodes slightly increased across the first four group tasks, and showed a sudden decrease for group B along with a slight decrease for the group A during the last activity.

In terms of the co-regulatory monitoring episodes among students, the students in group B engaged in these processes during all the small group activities apart from

the second. For group A, the rates of such monitoring episodes among the students slightly increased across the first three activities and then suddenly increased in the fourth activity, followed by a sharp decrease during the last. Moreover, this group engaged in more co-regulatory monitoring episodes among its members than group B, thus implying that there were more asymmetrical interactions among the former than the latter

Figure 5.7 – Rates per session of the episodes of monitoring and control processes focusing on the motivational aspect across the small group activities



Furthermore, when considering the rates of emotional and motivational regulation episodes across the small group activities over time, the findings also show quite different patterns for the both groups. Regarding this, as can be seen from Figures 5.6

and 5.7, during the first small group activity group A only engaged in those shared control processes that were focused on the motivational aspect of their learning (see Subsection 4.3.3 for typical shared regulation episodes), whilst during the second activity the only evidence of co-regulatory control was that with their teacher. For the third activity, this group engaged in self-regulatory monitoring and self-regulatory and shared control processes in order to overcome the socioemotional challenges they experienced within their group. In the fourth activity, they regulated only the motivational aspect of their learning, engaging in individual and shared monitoring as well as shared control processes. For the last group activity, they exhibited both socioemotional and motivational experiences, and used individual and shared monitoring as well as shared control processes.

In the case of group B, the rates of shared control episodes focusing on motivational aspects of student's learning showed an increase across the first three activities, followed by a slight decrease during the fourth activity and a sudden decrease in the last. Moreover, these students showed evidence of self-regulatory monitoring episodes only in the second group activity. In addition, although co-regulatory control episodes with the teacher were observed during the first two activities, no such monitoring or control processes were found among students for any of the group tasks. Further, this group engaged in self-regulatory monitoring and shared control processes to overcome socioemotional challenges only in the last group activity and there was also evidence of a shared control process in relation to motivational aspect at this time.

In general, although different patterns were identified for groups A and B, all the students in these groups appeared to engage in increased numbers of emotional and motivational regulation episodes over time. In particular, these groups encountered socioemotional experiences during the last three activities. One possible explanation for this may relate to the characteristics of the small group activities, in particular, the level of difficulty, whereby, as pointed out above, more challenging tasks were introduced chronologically and this could have stimulated negative emotions or low levels of motivation among the students. In addition, this can be also related to the increased familiarity amongst group members over time, as they may have felt more

comfortable in expressing their negative feelings or low levels of wishing to engage, as well as using strategies for controlling their motivational and emotional states.

5.4.2 Changes in regulation of learning processes within groups A and B

This section looks into the students' use of regulation of learning processes over time within groups A and B, taking into account the profiles of each and the characteristics of the group tasks.

Group A

Group A was composed of three members, one male (Kutay) and two female students (Leman and Ayse), whose group profile is illustrated in Table 5.1. As a mixed-ability and self-selected group, all three explained that their main goal during science lesson was learning, for they found studying these topics interesting and meaningful for themselves.

Interviewer (I): OK, what do you think, why are you learning these science topics?

Ayse: I don't know, the topics are so interesting, and it is, I think, important for us to have some knowledge about them.

I: Ok, Kutay, what do you think?

Kutay: Science is a very fun lesson, since we examine our body structures. It is usually very interesting, I mean, I like it.

I: Alright, which system do you most like?

Kutay: Well, I suppose, the nervous system is fascinating for me, but as well as the most difficult one.

Leman: It is also interesting for me, because I have been always wondering about the brain since I was a little kid.

I: OK, anything else, about your feelings?

In their group interview, when asked why they decided to join the same group, Leman and Ayse explained their close long term friendship with each other as the most important factor in terms of being in the same group, while Kutay explained that he was invited to join the group, since he had not been in any group as he was absent during the first lesson in which all the groups were formed. These explanations indicate the existence of strong social ties between Ayse and Leman

prior to the small group activities, while Kutay had less strong ones with the other group members.

- I: OK, let's talk about your group now, some questions about the group work. First of all, how did you form your group? How did you decide to work together?
- Leman: First of all, two of us are really good friends (*pointing at Ayse*), so we try to be together in all lessons.
- Ayse: Yes, we have been friends for more than 7 years.
- Leman: So, we wanted to be in the same group because of this.
- I: What about you, Kutay?
- Kutay: Actually, I missed the first lesson in which the groups were selected. So, I wasn't in any group and they told me that we could work together, and then I joined them.

In addition, asymmetrical ties were identified among these students in terms of leadership. That is, Leman was identified as having a high level of leadership by her teacher and the researcher (me) and Ayse was recognised as having a moderate level, whereas Kutay exhibited a low level of such skill.

Table 5.1 – Profile of Group A

Students	Kutay (<i>male, mid-achiever</i>)	Leman (<i>female, high-achiever</i>)	Ayse (<i>female, mid-achiever</i>)
Personal achievement goal	Learning oriented	Learning oriented	Learning oriented
Friendship	Moderate with all	Close with Ayse Moderate with Kutay	Close with Leman/ Moderate with Kutay
Leadership level (<i>The teacher and the researcher's reflection</i>)	Low	High	Moderate
Roles within the	Not interested in	Intellectual/ leader	Science lover

group	group activities/ often distracting the others	Idea provider/ help giver/ reviser/ ideas collector	
Ideas about the role of group work	Developing a team spirit/ making students love learning (<i>describes what experts think</i>)	Sharing and discussing viewpoints with each other/ achieving more accurate understanding/ enabling effective communication/ having more enjoyable learning	Providing a positive learning atmosphere/ helping each other's learning/ improving social skills/ providing more fun and enjoyable learning
Ideas about the role of the teacher	Checking the group's progress	Guiding the students' learning/ help giver/ monitoring the group's understanding and progress	Guiding students' learning/ help giver/ monitoring the group's understanding and progress

These students also explained their roles within the group, as shown in the following excerpt. Leman self-identified as an idea provider, help giver, ideas collector and reviser, while she was also recognised by her group friends as an intellectual and group leader. Ayse explained her role as a science lover and contributor to the group's functioning, while Kutay considered himself as "someone, not interested in learning, who distracted others" in one comment, even though he was observed to be actively involved in the group discussions.

- I: OK, um, Kutay, what is your role within your group?
- Kutay: Someone, not interested in learning.
- Leman: True (laughing).
- Kutay: Distracting others.
- I: And yours, Leman?
- Leman: Mine?
- Kutay: Intelligent.
- Ayse: Hardworking.
- Leman: I don't know.

- I: For instance, explain to us why you are important for your group, your speciality?
- Leman: OK, I am explaining. I always summarise what we have done, and I do my homework.
- I: But during the group work?
- Leman: My role within the group is to make explanations or suggest ideas for what my friends don't understand.
- I: Anything else?
- Leman: I am a very talkative person and I usually collect each of our ideas.
- Ayse: Like a leader.
- Kutay: Actually, she is the group leader.
- Leman: Am I?
- Ayse: Yes, we had an election.
- Leman: I yeah, I totally forgot this.
- I: OK, this is Ayse's turn, what is your role within the group?
- Ayse: My role is that I am someone who like science, but who doesn't like studying. But when I am with this group of friends, I can really focus on studying and make contributions as much as I can.

In addition, with regards to their ideas about the role of group work, Kutay considered it as not being important for himself, explaining it in terms of what experts claim to be its advantages, rather than concurring with its benefits. Whereas Ayse and Leman put forward several personal and social goals which they believed that they could be achieved through learning as a group. For instance, Leman considered group work to be invaluable in terms of sharing and discussing viewpoints with each other, achieving more accurate understanding, and having more enjoyable learning as well as effective communication. Ayse also expressed the view of group work as being supportive, providing a positive learning atmosphere in which they could help each other's learning, improve their social skills, as well as have enjoyment whilst learning.

- I: OK, the next question, why do you think that the group work is important?
- Kutay:
- Kutay: Group work isn't really important for me, but in fact, according to the experts, it helps in developing team spirit.
- I: Anything else?

Kutay: Um, it is something makes us to love studying, and so on.

I: What do you think, Leman?

Leman: I think, the group work is important in terms of exchanging ideas with a few people, because if you only have own, you aren't able to check whether it is correct, but if there is more than one person, you are likely to be shown your mistaken thinking, or something different than what you are thinking.

I: OK, Ayse, what do you think?

Ayse: I think, it changes from group to group. Like...

I: For instance, in your group?

Ayse: If you are in a group with Leman, definitely, it is a very good thing.

Leman: *(laughs)*

Ayse: Because, when we think together, she always tells me what I don't understand. Also, I think, it is important that you are in a group with people whom you get along with.

Leman: Yes, that way communication also becomes effective.

Ayse: Also, our group provides an environment, in which I can share my ideas and thoughts without being shy, in a comfortable way.

Leman: I think that it is better than working alone and also more enjoyable.

I: Why?

Leman: I think, sharing and discussing viewpoints with someone else is more enjoyable and better. For instance, if you have a partial answer, when members say what they think, the possibility can arise for finding out the whole answer.

I: Ayse?

Ayse: Of course it is very beneficial. Like, when I study at home alone, I get bored so easily. And since there is a friendly atmosphere in the school, being a group together is more fun. For me, when I am in the group, everything seems so much easier to me.

As these explanations illustrate, while Ayse and Leman had a sense of belonging and strong positive feelings towards the role of group work, Kutay exhibited a somewhat different perspective, being less positive and more ambivalent about it. Furthermore, as the above excerpt shows, Ayse and Leman showed a higher level of mutual trust within their group, emphasising the advantages of working in the same group in which they could receive academic and emotional support from each other.

The students were also asked to express their views about the role of the teacher during group work. Regarding this, while Leman and Ayse identified her role as supporting and guiding their learning and monitoring group understanding and progress, Kutay considered it as only pertaining to the lattermost function (some of the episodes described in Chapters 4 and Chapter 6 illustrate typical dialogues exemplifying the interactions of group A during the small group activities).

Figure 5.8 illustrates the rates of metacognitive regulation episodes in terms of involvement of each member of group A over time across the small group activities. In this figure, it can be seen that the overall trend was that all three students engaged increasingly in more shared metacognitive regulation processes over time. This finding provides evidence of increasing symmetrical interactions occurring among them as they progressed through the group activities. In terms of their involvement in shared regulation episodes, Leman had the highest rate across these activities, whereas Kutay engaged in fewer of these when compared with his partners. This outcome is understandable given the student characteristics, such as the level of participation in the group as indicated in Table 5.1. In this regard, the highest level of shared regulation displayed by Leman probably relates to her participation roles within the group discussions, as she described more and effective participation roles than her partners. This finding also appears to be related to the quality of the interpersonal relationships among the group members. That is, the reason why Ayse and Leman engaged in more shared regulation processes can be attributed to the higher level of mutual trust between the two or their perceptions of academic and emotional support received from each other within the group, which in all probability promoted mutual and reciprocal interactions among each other, a prerequisite for shared regulation of learning.

In terms of the co-regulatory metacognitive episodes among these students, Kutay and Leman exhibited higher rates in comparison with Ayse across the group activities. This finding shows that most of these episodes occurred between Kutay and Leman, while there was significantly less asymmetrical interaction occurring between Ayse and her partners. Moreover, Kutay had considerably more individual metacognitive episodes than Leman and Ayse and this finding could be as a result of

his need to refer often to his individual understanding of what was being discussed during the group activities.

Figure 5.8 - Rates per session of the metacognitive regulation episodes for each student (Group A)

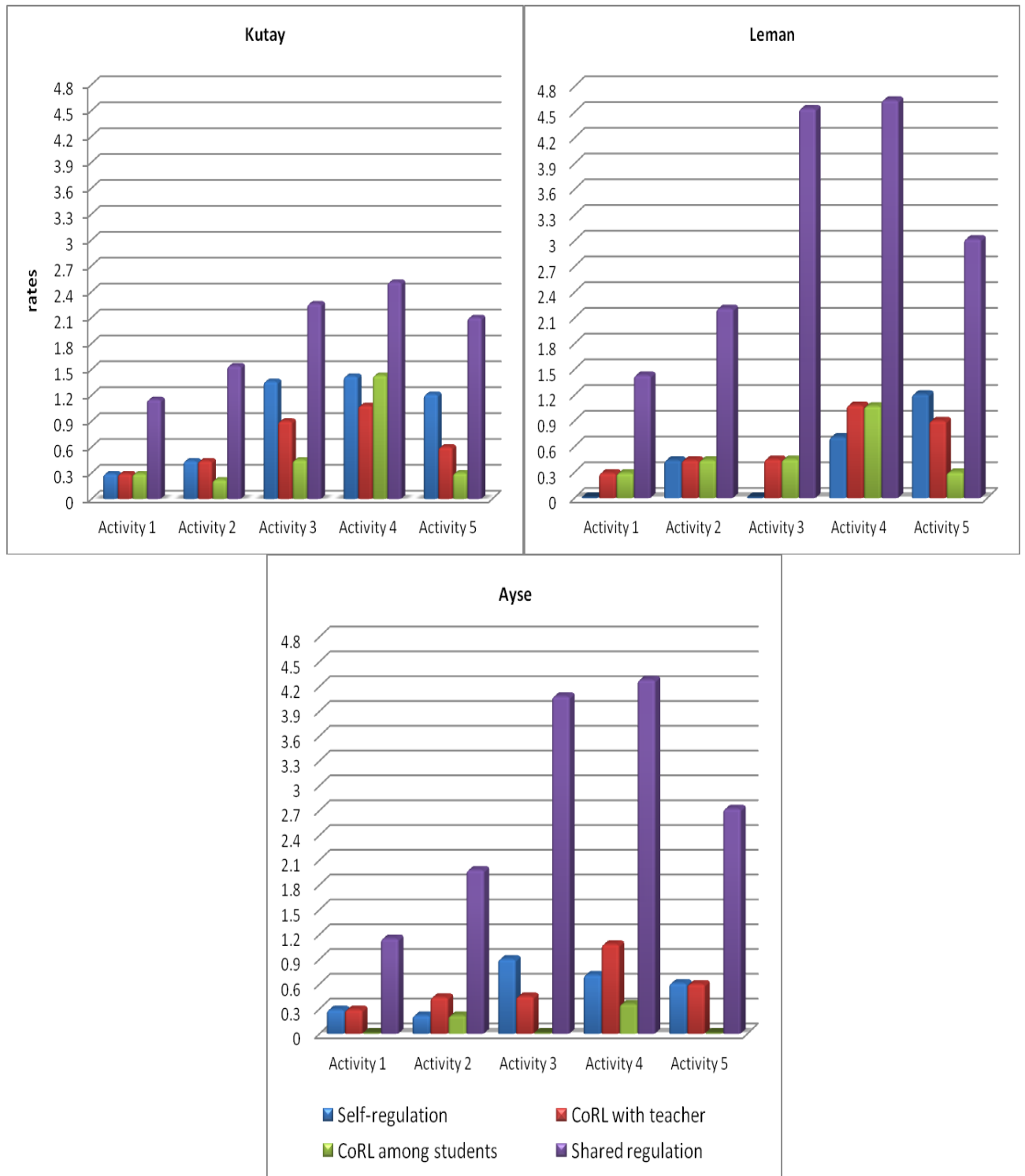
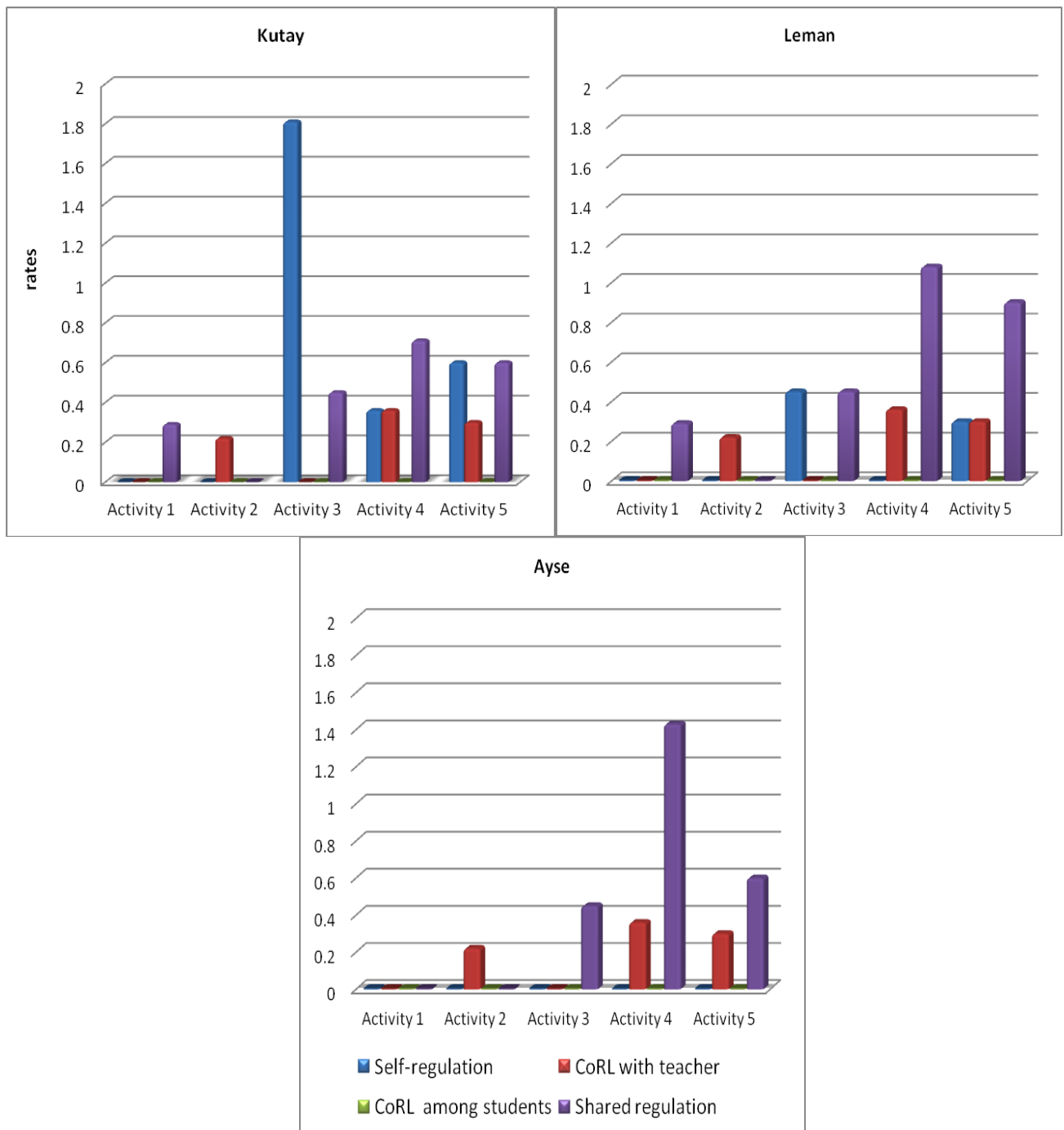


Figure 5.9 - Rates per session of the emotional and motivational regulation episodes for each student (Group A)



As shown in the Figure 5.9, the group members differed in relation to their involvement in the episodes of emotional and motivational regulation across the small group activities. In terms of self-regulation episodes, Kutay had the highest rates, with Leman coming next with somewhat fewer, whilst no such regulation was

identified for Ayse. This finding can be explained by the quality of the interpersonal relationships among the group members. That is, the reason why Kutay individually monitored and controlled his emotional and motivational states more than his partners can be explained due to the less strong social ties he had with his partners, which could have the potential for creating more socioemotional challenges for him whilst interacting with them. In addition, this finding can be attributed to the different levels of mutual trust and safety the students had developed towards each other within the group, whereby Leman and Ayse experiencing a strong bond in this regard faced fewer individual emotional and motivational challenges during the group tasks.

Notably, the rates of shared emotional and motivational regulation episodes illustrate only small differences between the group members and as already explained, all three students experienced an increasing trend of using more shared emotional and motivational regulation processes over time across the small group activities. This result suggests that while group A encountered a number of socially challenging situations, all students were willing to invest their energy in maintaining positive emotional and motivational engagement during the learning tasks. This finding may also indicate the chronological development of an enduring sensitivity in relation to socioemotional and motivational support within this group.

Group B

Vural (male), Brus (male) and Ezgi (female) comprised another self-selected and mixed ability group, whose group profile is illustrated in Table 5.2. Similarly to group A, all the group members had learning-oriented goals concerning the scientific inquiry activities. As the excerpt below illustrates, they considered learning science as important and motivating for themselves.

- I: As you know, at the moment, you are studying the topic about the human body systems. What do you think, why are you learning these subjects?
Ezgi?
- Ezgi: Me, because I really get excited, when I learn about new topics or new information. And in this unit, my aim is to acquire some new knowledge about our body, how the systems work.

- I: Anybody else?
- Vural: I think that it is very important for us to know how the systems work in our body. I think, we really need some knowledge of them as we may use in the future.
- I: OK, thanks. What about you, Brus?
- Brus: I agree with my friends. For instance, we can use the knowledge of the digestive system to eat properly, or in case of any health problems, we can know which doctors we will need to see.

In their semi-structured interview, when asked about why they had decided to work in the same group, the students explained their close and enjoyable friendship with each other as the main reason of joining in the same group. This provides evidence for the existence of strong social ties among the group members. Moreover, as Table 5.2 shows, the students in this group had more symmetrical ties in terms of leadership compared to group A.

Table 5.2 – Profile of the Group B

Students	Vural (male, high-achiever)	Brus (male, mid-high achiever)	Ezgi (female, high-achiever)
Personal achievement goal	Learning oriented	Learning oriented	Learning oriented
Friendship	Close with all	Close with all	Close with all
Leadership level (The teacher and the researcher's reflection)	Moderate	Moderate	High
Roles within the group	Contributor/ help giver	Contributor/ ideas provider	Engager / consensus seeker / ideas provider / mediator
Ideas about the role of the group work	Combining different ideas/ helping less	Sharing and discussing viewpoints with each other/ developing a	Sharing ideas with each other/ developing a positive social relationship (a close

	successful students	positive social relationship/ achieving more accurate understanding	<i>friendship</i>)/ combining different ideas/ providing an entertaining and enjoyable atmosphere
Ideas about the role of the teacher	Guiding students' learning/ explainer and clarifier of ideas/ implicit help giver	Guiding students' learning/ implicit help giver	Guiding students' learning/ explainer and clarifier of ideas/ implicit help giver/ initiator of new ideas or perspectives

The students also explained their participation roles within the group, with Vural self-identifying as a contributor and help giver, whereas Brus explained that he was an ideas provider and contributor to the group's functioning. Similarly, Ezgi considered her role as that of an ideas provider, but also described herself as an engager of the group with the set activity as well as a mediator when conflicting ideas emerged within the group. Moreover, as the following excerpt shows, she was recognised by her partners as a very highly respected and congenial person who provided social and emotional support when the group could not reach agreement concerning its shared understanding.

- I: Right, next question, what do you think about your roles during the group work? Ezgi?
- Ezgi: I don't know, I think, I try to engage others in the discussion.
- I: When, how?
- Ezgi: When we have different opinions about something, sometimes, we can't agree with each other and I try to find the common ground.
- Vural: Actually, Ezgi is a very congenial person. For instance, even if there is something which she already researched, she can also say that 'oh yes this can be like what you say' or she is able to listen and consider our viewpoints.
- Brus: Yes.
- Vural: But, Brus and I are completely different. Sometimes, even if we aren't really sure, we just stick to our ideas, as we can't really see which idea is correct or wrong. Also, Ezgi gets confused as she wants to reach an agreement with both of us.

- Brus: I usually try to contribute to the discussion. I share what I am thinking as well as make suggestions sometimes.
- I: Vural?
- Vural: Um, similar to Brus, I try to participate in the discussion and contribute with my knowledge.

In terms of the role of the group work, the students expressed a variety of personal and social goals which they considered they could achieve when learning as a group. For instance, as shown in the following excerpt, Vural considered this type of work as beneficial in terms of combining different ideas and helping less successful peers. Brus also perceived the group work as invaluable, since it provided opportunities to share and discuss viewpoints with each other, achieve more accurate understanding and develop positive social relationships. Similarly, Ezgi also considered the group work as important in terms of providing an entertaining and enjoyable atmosphere in which they could share and combine each other's ideas, as well as strengthen their mutual friendship

- I: Ezgi, what do you think, what is the purpose of the group work?
- Ezgi: Sharing information. Actually, um, it may have a couple of purposes. First, we support each other and develop our relationship in terms of friendship.
- I: Yes.
- Ezgi: Apart from this, combining each of our ideas to see what knowledge we have.
- I: Yeah.
- Ezgi: These kinds of aims.
- I: You [Vural]?
- Vural: I have two different ideas about this. First one is for example, I have A, someone else has B, and the other person has C, when we combine all of them, we can make A B C.
- I: Right.
- Vural: Also helping some of the friends who are less successful, in order to engage them with the lesson.
- I: I see. What about you Brus?
- Brus: I think that the group work is done for solidarity as well as for sharing all the ideas in order to come to a conclusion.

- I: OK, for instance, in this group work, what was the most interesting thing you liked?
- Brus: What was it, everything was very good.
- Ezgi: First of all, we answered all of the questions and shared all of our ideas and the ideas were really excellent. Apart from this, it was fun and entertaining. I think, our group is really enjoyable. We also talked about other issues which were really fun, not just about the group task, and we laughed a lot.
- I: Vural?
- Vural: I also mostly enjoy the group work.
- I: Why?
- Vural: Because everyone usually has an idea, and I think we have been always able to reach a correct decision.
- I: Anything else, Brus?
- Brus: In fact, I prefer group work rather than individual study, because for instance, when studying individually, when we make a mistake, we do not realise it easily, but when working as a group, our group mates can correct our mistakes, or I can also correct their mistakes too. So we can reach a shared decision.
- I: Ezgi.
- Ezgi: Group work of course is important, but there also some benefits of individual study too.

As these explanations reveal, in contrast to group A, all the students had a clear sense of belonging and positive feelings towards the role of group work. Moreover, the group members appeared to have built a consensus on the importance of sharing and discussing all their ideas as well as maintaining positive social relationships while working together. Furthermore, these explanations also provide evidence of a feeling of safety existing among all members within this group, in particular, as its members emphasised the importance of academic and emotional support given by one another while working collaboratively.

As the following excerpt illustrates, similar to group A, the students had positive views about the role of teacher for the group activities. That is, all the group members considered the role of teacher as guiding their learning process and giving help through explaining and clarifying their ideas when necessary. In addition, Ezgi identified an aspect of their teacher's role as that of initiating new ideas or

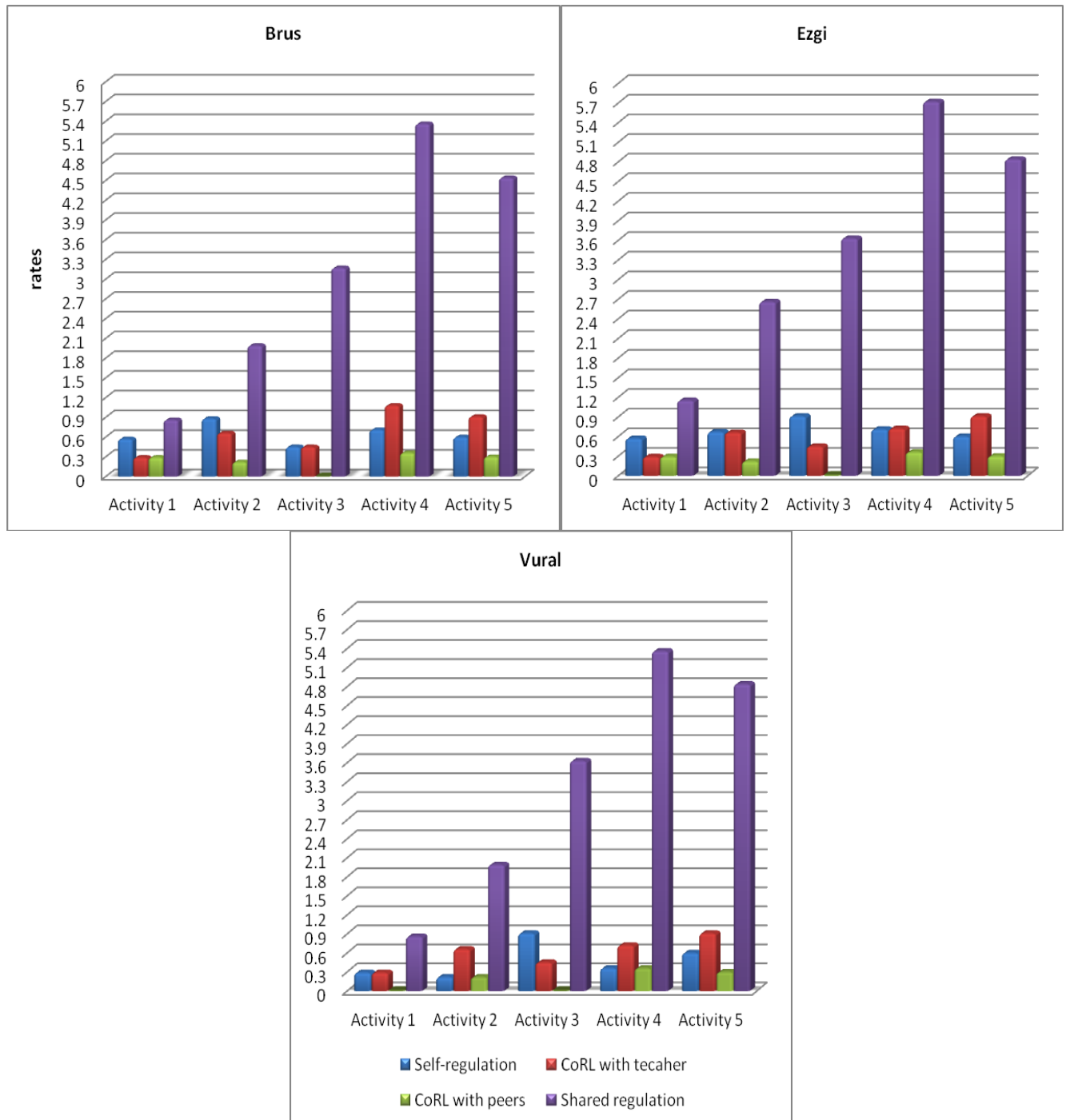
perspectives about the group tasks. As with group A, some of the episodes presented in the analysis chapters provide typical dialogues exemplifying the interactions of group B during the small group activities.

- I: OK, your next question is, what do you think about the role of teacher, especially when she visits your group?
- Ezgi: She is really helpful. She tells us some of the answers, but not exactly the whole answer.
- Brus: Yes, she explains how we can reach the answers.
- Ezgi: Yes, she tells us if we are doing it wrong or are correct.
- I: Vural?
- Vural: First of all, she guides us, asking some question. If there is anything which doesn't make sense to us or any question we cannot solve, she usually helps us. She doesn't provide the answers, but this is good, because the questions are supposed to be answered by us.
- I: Ezgi?
- Ezgi: She also gives some perspective to us, like showing us ways to think about the problem.
- I: For instance, any examples?
- Ezgi: For example, when we asked the teacher about the ADH hormone, she didn't provide complete answer, but she gave more information about the ADH hormone.
- Vural: Then, she always tells us that she has nothing to say more about this and please find the answer yourself.
- Brus: And in our group work, if one of us cannot find an answer, others usually can help, but the support from the teacher is also important.

Figure 5.10 illustrates the rates of metacognitive regulation episodes in terms of involvement of each member of the group B across the small group activities. As this figure illustrates, likewise with group A, all the group members experienced a trend of engaging increasingly in more shared metacognitive processes over time. This finding indicates more symmetrical interactions occurring among the members of group B, as they progressed through the group activities. However, unlike group A, there was not very much difference in terms of involvement of each student in shared regulation episodes. As explained earlier, this result can be attributed to the quality of interpersonal relationships among the group members. That is, the reason why the

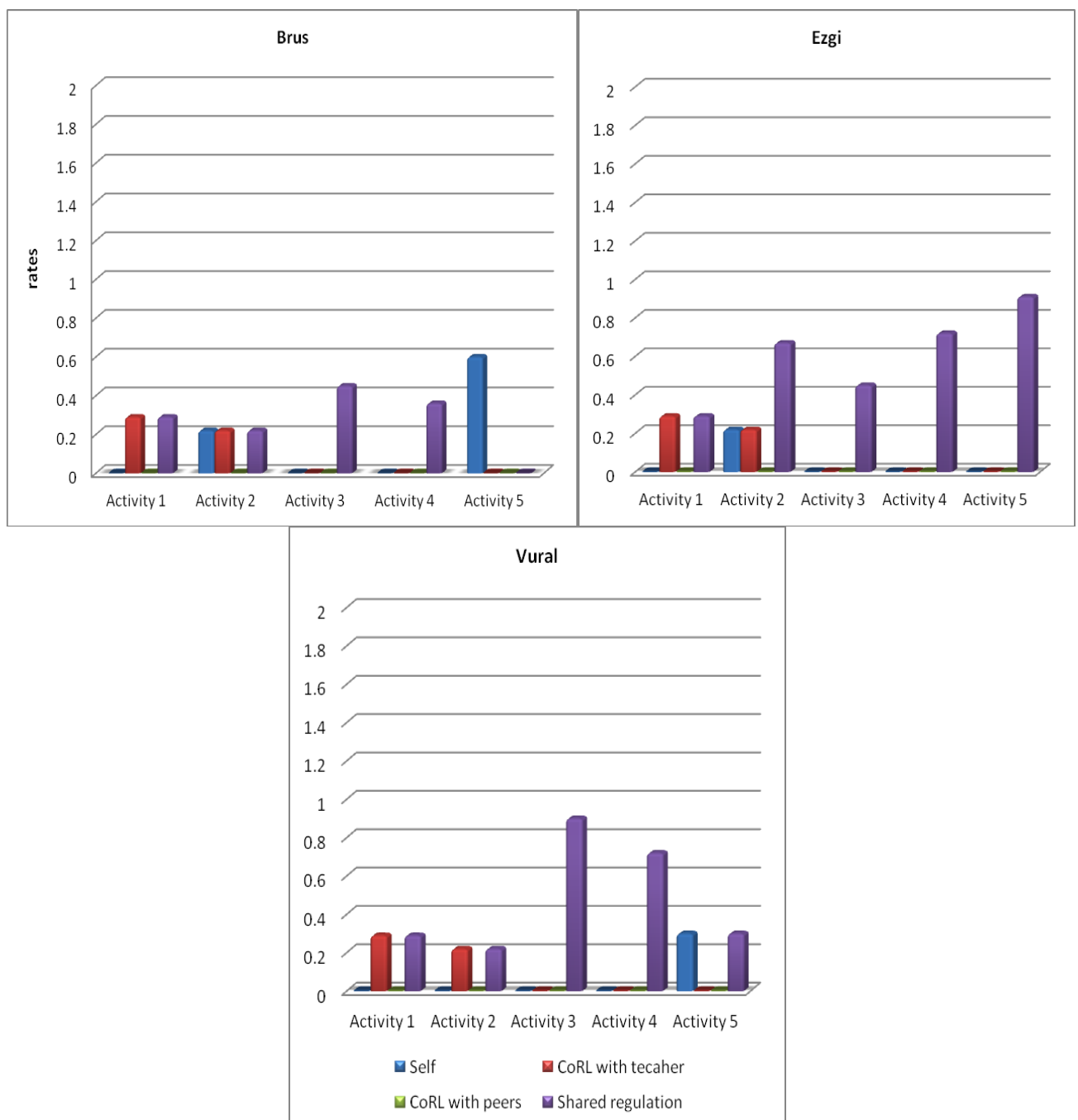
students had similar rates of shared regulation processes across the small group tasks is more likely due to the existence of positive and supportive social relationships within group B, which could promote mutual and reciprocal interactions amongst its members.

Figure 5.10 - Rates per session of the metacognitive regulation episodes for each student (Group B)



In terms of self-regulation, the rates fluctuated across the group activities, with Brus and Ezgi being observed to engage more in such monitoring processes as compared to Vural. Furthermore, all the group members showed similar rates of co-regulation episodes among themselves with slight fluctuations across the group tasks. This finding provides evidence for the existence of asymmetrical interactions occurring among all the members of group B during their engagement in the group tasks.

Figure 5.11 – Rates per session of the emotional and motivational regulation episodes for each student (Group B)



Akin to group A, group B also showed differences in their involvement in the episodes of emotional and motivational regulation processes over time. As Figure 5.11 illustrates, Brus engaged in more self-regulation episodes during the group activities than his partners, who only used a few individual regulation processes. Furthermore, the episodes of shared emotional and motivational regulation for Ezgi and Ural represented highest rates of the use of any regulation process. This willingness to invest energy in order to maintain the group's emotional and motivational engagement with the tasks can be explained given the social learning goals the students held within their group. That is, all these students expressed commitment to the collaborative activities and viewed group work as important in terms of presenting an entertaining and enjoyable atmosphere in which they could share and combine each other's ideas as well as develop positive social relationships with each other.

5.5 Chapter summary

With regards to addressing the second research question, the analyses carried out in this chapter reveal salient differences in the patterns of the students' use of regulation of learning processes over time across the types of learning activities as well as between and within groups A and B.

At first sight, the findings concur with previous research that elicited that self and social forms of regulation processes used by students are associated with the types of activities and pedagogical interactions (Hadwin *et al.*, 2011; Hurme *et al.*, 2009; Volet *et al.*, 2009b; Whitebread *et al.* 2007). For instance, the teacher-led introductory and whole class discussion activities, which provided less opportunity for collective interactions among the students, predominantly included episodes of metacognitive co-regulation processes with the teacher. In contrast, in the collaborative small group activities, which typically involved mutual and reciprocal collaborative interactions among the students, the groups mostly utilised shared metacognitive regulation episodes in which they collectively planned, monitored or evaluated their cognitive processing towards a shared goal. Likewise, co-regulation episodes where the teacher controlled the students' emotional and motivational states had the highest rates during the introductory and whole class discussion activities,

whilst the students mostly showed evidence of self-regulatory and shared monitoring and control processes during the small group activities.

Moreover, in terms of changes in the use of the regulation processes, the findings suggest that while there was no clear evolution in their use for introductory and whole class discussion activities, the general trend was that the student groups engaged progressively in more shared regulation processes over the sequence of small group activities. This indicates that the patterns of interactions remained chronologically mostly asymmetrical across the sequences of whole class activities, with the students most commonly engaging in co-regulation processes with the teacher. In contrast, the student groups interacted with each other increasingly in more symmetric ways in terms of regulating their joint learning, as well as increasingly experiencing and overcoming more socioemotional and motivational challenges along the sequence of small group activities. As mentioned earlier, this increase can be attributed to the increasing difficulty level of the group tasks. According to previous research (e.g., Iiskala et al. 2011; Vauras et al., 2003), regulation processes tend to emerge more frequently in appropriately, cognitively challenging learning tasks than easy or extremely difficult tasks. Similarly, in this study, it was observed that students engaged in more shared regulation processes in difficult tasks than the tasks characterised as less difficult. Moreover, this could be associated with the internalisation of ground rules which the teacher wanted to happen as witnessed by her continued emphasis on the shared responsibility and active collaboration required among the students for the small group work. In addition, the social climate created within each group over time could be another reason for this increase, as will be discussed in the next chapter, positive types of interactions among the group members helped in establishing a supportive social climate within the groups that appeared to promote and facilitate the emergence of shared metacognitive regulation processes.

However, while the student groups increasingly used regulation processes, the analysis also elicited some notably slight differences in the trajectories of the development for each group as well as for the group members. For instance, the rates of metacognitive regulation episodes distinctly varied in each small group activity for groups A and B. Also, noticeable variations in the rates of regulation episodes in

terms of the involvement of each member of groups A and B in the tasks emerged. Regarding this, the data gathered from the group interviews provided evidence that some of the individual and group level characteristics appeared to be a determinant for these intergroup and within-group differences. For instance, as explained in Subsection 5.4.2, the students' social learning goals or participation roles during collaboration were identified as being associated with their use of regulation processes.

Further, the quality of interpersonal relationships in terms of perceived levels of emotional and academic support, and the nature of friendships (or social ties) existing within each group seemed to shed light on some of the differences between and within groups A and B. Some of the extant literature supports this finding by showing links between the quality of interpersonal relationships and effective group functioning. For instance, in a study conducted with upper elementary students during small group mathematics tasks, Rogat and Linnenbrink-Garcia (2011) identified the presence of positive interactions as facilitating students' use of higher quality social regulation processes. Similarly, a number of researchers have pointed out the important role played by the supportive, positive quality of interpersonal relationships and interactions in promoting effective collaboration among students in small group learning situations (Blatchford *et al.* 2006; Kempler & Linnenbrink, 2006; Kutnick & Colwell, 2010).

Nevertheless, while this chapter and Chapter 4 have provided some notable results in terms of students' regulation of their learning processes, there remain a number of issues which call for further attention. First, although the analysis has revealed some findings in terms of how the focal students' regulation of learning processes changed over the sequence of scientific inquiry activities as well as across the student groups, we still do not know how and when these regulation processes emerge and what functions they have on solo and joint learning processes. Second, whilst these results have elicited the role of the quality of interpersonal relationship in students' use of regulation processes, it is still unclear how it may promote or constrain their engagement with them. Therefore, in the next analysis chapter, in order to shed light on these issues, a further qualitative analysis is carried out exploring when and how social forms of metacognitive regulation episodes emerge, how they influence

students' learning, as well as whether and how the quality of interpersonal relationships may be related to these regulation processes during scientific inquiry learning activities.

Chapter 6 – Emergence and Function of Social Forms of Metacognitive Regulation Processes

6.1 Introduction

As explained in Chapter 2, while social forms of metacognitive regulation are often illustrated in the literature, there is a limited understanding of how these processes emerge as well as in which ways they function (Iiskala *et al.* 2011; Volet *et al.* 2009a, 2009b). Thus, in addressing the research question 3, the analyses described in this chapter explore the themes in the emergence of social forms of metacognitive regulation episodes and the functions of these episodes as students participate in scientific inquiry activities. Furthermore, as Chapter 5 has elicited some links between students' regulation of their learning processes and the nature of interpersonal relationships, such as in terms of the perceived emotional and academic support or the nature of friendship, this chapter looks into the role of the quality of interpersonal interactions (supportive or non-supportive) in social forms of metacognitive regulation episodes.

6.2 Data analysis

As explained in detail in Subsection 3.6.3, all the social forms of metacognitive regulation episodes identified in Chapter 4 were analysed thematically, using the NVivo software package, in order to explore when and how social forms of metacognitive regulation processes were most commonly initiated by the students or the teacher during the scientific inquiry activities. This analysis involved identifying and describing the utterances and/or nonverbal actions which appeared to be the initiating moment of the episode. On the basis of this analysis, the emerging themes were identified and refined through an iterative process. In addition, another qualitative analysis was carried out with the purpose of examining the functions of social regulation episodes belonging to the emerging themes. All the themes were discussed with my supervisors and another researcher with the purpose of confirming

the veracity of the analysis. The frequency counts of episodes illustrated the major themes originating from the analysis of the video and stimulated-recall interview data.

Also, the quality of the interpersonal interactions was analysed in relation to the social forms of metacognitive regulation episodes. This quality refers to the socioemotional aspect of student-student or teacher-students interactions in which the students and/or teacher supported or undermined each other's engagement with a learning activity. Akin to Kempler and Linnenbrink's (2006) analytic approach, in this analysis, interpersonal interactions (verbal and nonverbal) were characterised as positive when the students or teacher showed evidence of verbal and/or nonverbal interactions which were supportive and encouraging of one another (e.g., making eye contact, showing mutual respect, paying close attention to each other's ideas or showing mutual participation). In contrast, interpersonal interactions were considered as negative when the students or teacher discouraged another student's participation in the task or disrespected each other (e.g., using excess criticism, ignoring or not responding to one another's suggestions).

6.3 Metacognitive co-regulation

This section describes when and how the episodes of metacognitive co-regulation emerged during the whole class and small group scientific inquiry activities. Four major themes identified from the analysis of data illustrate that metacognitive co-regulation processes commonly emerged when the students (a) articulated a misconception, (b) expressed a lack of understanding, (c) articulated a tentative idea, or when (d) the teacher intended to use peer assessment to check and discuss their ideas with the class (see Table 6.1). Furthermore, evidence was provided that there was a positive quality of interpersonal interactions during the metacognitive co-regulation episodes. These findings are discussed with the illustrative episodes in this section.

Table 6.1 Frequency and percentages of the themes regarding the emergence of metacognitive co-regulation episodes across the different types of inquiry activities

Themes	Introductory activities		Whole class discussions		Small group activities		Total	
	(F)	(%)	(F)	(%)	(F)	(%)	(F)	(%)
Expressing a misconception	1	7.1	6	18.75	5	16.1	12	16.2
Expressing a lack of understanding	2	14.2	0	0	8	25.8	10	13.5
Articulating an idea in a tentative way	0	0	4	12.5	1	3.23	5	6.75
Using peer assessment	4	28.5	8	25	0	0	12	16.2

Note: The frequencies and corresponding percentages are out of the total number of metacognitive co-regulatory episodes for that particular activity.

6.3.1 Expressing a misconception

The students and teacher often engaged in metacognitive co-regulation episodes when one of the students expressed a misconception during a whole class or small group activity. During these episodes, they made explicit their misconceptions while externalising their ideas, which informed their teacher or peers about their thinking. These co-regulation processes usually had the function of stimulating students to be aware of their misconception and hence resulted in constructing new understanding.

The following episode coming from the '*poisonous plant*' small group activity exemplifies this type of co-regulation. In this part of the activity, group B is trying to identify the responses created by the nervous system while playing football by discussing their observations and applying the knowledge which they have learnt in the previous lessons. At the beginning of this episode, Ezgi reads the inquiry

question out aloud (turn 1) and Brus states his opinion which reveals his misconception about the conditioned reflex (turn 2). Next, Ezgi glances at Brus with raised eyebrows and elaborates upon his misconception, which prompts Brus to reconsider his initial idea (turns 3 & 5). Then, Brus becomes aware of his misunderstanding and puts forward a new idea in the form of an implied question in which he requests a judgment of his current understanding from his peers (turn 6). In response, Ezgi glances at Brus again and affirms his perspective (turn 7). Towards the end of the episode, after Brus has completed his explanation, Ezgi and Vural provide a judgment regarding his understanding by elaborating upon his idea (turns 9 & 10).

Episode 6.1 – Small group activity 4 (Group B)

- 1 E: ‘What are the events which the child’s nervous system creates responses to during the match?’ (*reads the question*).
- 2 B: Responses nervous system creates, which means only the conditioned reflexes (*looks at his partners*).
- 3 E: I think (*glances at B with raised eye brows*), the responses created by the nervous system means that it can be any response to any event, not just the conditioned reflex.
- 4 B: What (*gazes at E with a confused look*)?
- 5 E: Something like for instance, any response the brain creates (*glances at B*).
- 6 B: Oh, yeah. Um (*thinking for a second*), it is like a player’s reaction to the ball (*his tone of voice indicates indirect questioning*)?
- 7 E: Yes, as a goalkeeper (*glances at B*).
- 8 B: When he misses the ball, the brain tells him to take the ball (*looking at his partners*).
- 9 E: Yes, so this is a response which the brain is involved in (*writing*).
- 10 V: Yes, this can be one of the responses.

As the episode indicates, by means of a process of metacognitive co-regulation which focused on Brus’s thinking (turns 3, 5, 7, 9 & 10), Ezgi and Vural assisted him in clarifying his misconception and constructing a new scientific understanding. Supportive interpersonal interactions were also visible in this episode in the form of the group members mutually respecting and attentively listening to each other by

making eye contact, paying close attention and responding to ideas put forward coherently.

6.3.2 Expressing a lack of understanding

Episodes of metacognitive co-regulation processes were also identified in which students articulated a lack of understanding during the introductory or small group activities, and during these episodes, they usually requested assistance from their teacher or peers while expressing their thinking. Co-regulation processes in these episodes had the function of helping them clarify their thinking and construct a new scientific understanding.

The following episode exemplifies this type of co-regulation process. In this episode, just before the whole class discussion in which students are to share their ideas regarding the inquiry questions investigated in the '*poisonous plant*' small group activity, group A engages in revising their answers one last time. At the beginning, after getting Leman's attention and articulating his lack of understanding, Kutay seeks help from Leman about how one of the events identified in their observations is carried out by the nervous system (turns 1 & 3). Next, Leman looks at Kutay and provides an explanation of what happens in the nervous system when the child touches the poisonous plant (turn 4). Then, Kutay attempts to clarify what he understands from Leman's explanation, requesting an assessment of his comprehension (turn 5). In response to Kutay, Leman glances at him and provides a judgment on his understanding (turn 6). In the last turn, Kutay appears to construct a new perspective through internalising Leman's viewpoint.

Episode 6.2 – Small group activity 4 (Group A)

- 1 K: Leman, I will say something (*looking at L*).
- 2 L: (*glancing at K*)
- 3 K: You know, he pulls his hand away first and then screams. I don't understand this really. What is he doing there, a reflex? (*smiles*)
- 4 L: Firstly, he pulls his hand away as a reflex, and then the impulse goes to the brain, and the brain tells him to scream and so he screams (*looking at K*),

- 5 K: Yaaaah (*a rise in the volume of his voice*)! It goes to the brain (*pointing at his brain*), isn't it? First, it goes to the brain by means of spinal cord, and the reflex happens through the neuron cells (*using gestures and looking at L*).
- 6 L: No, after he pulls his hand away (*glances at K*).
- 7 K: Yeah, OK (*checking his notebook for two seconds*). I have got it correctly (*nodding*).

As can be seen, after Kutay communicated his lack of understanding, this led to intersubjectivity with his partner, whereby Leman provided him assistance in clarifying his thinking and constructing new understanding through engaging in a co-regulation process. During this asymmetrical interaction, Leman monitored Kutay's understanding and responded coherently to changes in his thinking. In this episode, there was evidence of a positive quality of interpersonal interactions in which the peers appeared to be supportive and respectful of one another by politely asking for and responding to help. Also, they attentively listened to each other by making eye contact and showing understanding of each other's perspectives.

The next episode taken from the '*water content of our body*' small group activity illustrates another example of expressing a lack of understanding. Here, group B is trying to figure out how the ADH hormone is secreted during the water level adjustment process in the human body. In turns 1 to 4, Ezgi and Vural share and affirm ideas with each other, and the former decides to write their joint explanation down in turn 5. Then, while Vural summarises the main points in their discussion (turn 6), Brus expresses puzzlement by asking for clarification about the role of the hypothalamus in the secretion of the ADH hormone (turn 7). Next, after Ezgi and Vural have provided a clarification and have elaborated upon their explanation (turns 8 to 13), Ezgi attempts to check Brus's understanding of the issue (turn 14 & 16), which prompts Brus to articulate his thinking (turn 17). In response to Brus, Ezgi and Vural provide further elaboration concerning his understanding (turn 19 & 20). In the last turn, Brus appears to construct new understanding and thanks his partners for their support.

(*Prior to Episode 6.3*)

- 1 E: According to the level of water, the brain... (*pauses*)

- 2 V: I think, it sends a signal to the pituitary gland (*looks at his partners*).
- 3 E: Right (*affirms*).
- 4 V: It sends information to the pituitary gland about how much ADH it needs to secrete.
- 5 E: Yes, I will write now (*starts writing*).
- 6 V: OK, I am explaining. This is the signal which comes from here (*explaining by using the diagram*). This one is sending it [signal] to here. Sorry, it is sent to the hypothalamus.

Episode 6.3 – Small group activity 5 (Group B)

- 7 B: But, one second, this ADH hormone, um (*seems confused*). Is the hypothalamus producing this hormone (*looks at his partners*)?
- 8 V: No (*speaks with a calm voice tone*), the hypothalamus is actually stimulating the pituitary gland.
- 9 E: Yes [affirms V]. Look here (*glances at B and points at the diagram*), the hypothalamus is stimulating the pituitary gland.
- 10 V: The hypothalamus is a section of the brain.
- 11 E: Yes, a part of the brain.
- 12 B: OK, it is inside the brain (*looking at his partners*).
- 13 V: Then, there is also a pituitary gland.
- 14 E: Yes, the pituitary gland is the one which is producing and secreting the ADH hormone. Is that alright? (*glances at B*)
- 15 B: Yes, OK.
- 16 E: This ADH hormone level goes down depending on the situation, OK?
- 17 B: In a sense, there is ADH in the pituitary gland?
- 18 V: I am getting thirsty (*smiles*).
- 19 E: Yes, according to the message, the hypothalamus sends a signal to the pituitary gland (*glances at B*).
- 20 V: It gives an order and the pituitary gland secretes hormones based on this information.
- 21 B: OK, thanks (*glances at his partners*).

In this episode, after Brus made his lack of understanding visible by expressing confusion and asking a question, Ezgi and Vural provided an assessment of his understanding by clarifying and elaborating upon the main points of the explanation. By means of co-regulation processes, the partners supported Brus in clarifying his thinking and constructing new scientific understanding. In addition, positive interpersonal interactions were evident within group B in this episode. For instance, the students appeared to be respectful of one another by attentively listening and responding to their partners' questions and ideas.

6.3.3 Articulating an idea in a tentative way

The students and teacher engaged in metacognitive co-regulation episodes when a student articulated an idea in a tentative manner during a whole class or small group activity. During these episodes, after the students made their thinking apparent while sharing ideas, their teacher attempted to guide them in clarifying their understanding.

The following episode coming from a whole class introduction about the topic of the '*endocrine system*' exemplifies this type of co-regulation process. Here, the class shares ideas and discusses how the hormones affect the target organs in the human body. From turns 1 to 4, Mrs. Celin probes the students' ideas about the consequences of what could happen if a hormone accidentally affects another organ, and they share their viewpoints with the class. Then, she asks further questions about how it becomes possible for a hormone to influence its target organ and calls upon Ezgi to share her point of view (turn 5). Next, after Ezgi presents her idea in a tentative manner by expressing uncertainty (turns 6 & 8), Mrs. Celin subsequently elaborates upon this, which challenges her thinking and stimulates her to reflect on her own perspective (turn 9). Although, Ezgi puts forward another idea (turn 10), this does not convince Mrs. Celin and she presents another challenging explanation concerning this new idea (turn 11). Subsequently, after Ezgi and Vural present their opinions (turns 12 & 13), she calls upon Ayb to share her opinion, but her perspective also does not convince Mrs. Celin. Finally, at the end of the episode, Mrs. Celin decides to share her own explanation with the class.

(Prior to Episode 6.3)

- 1 T: If a hormone goes to the wrong place (*pointing at the diagram on the whiteboard*), like if it goes to our lungs and stimulates it differently, what happens (*looks at the whole class*)?
- 2 V: That's bad.
- 3 Ez: Our lung can expand.
- 4 S: Our lungs would be damaged.
- 5 T: So, do you think this hormone travel in our blood so randomly? (*two seconds of silence*) Take the growth hormone for instance. It goes to the liver and stays there (*pointing at the diagram on the whiteboard*). Is this possible? Ezgi?

Episode 6.4 – Whole class discussion 4

- 6 E: What should I say (*stands up and looks uncertain*)?
- 7 T: How can it [hormone] know which organ it is going to affect?
- 8 E: I am not sure, but it can be special... I mean (*rise in the volume of her voice*), because it joins the circulatory system.
- 9 T: But, eventually, the blood circulates in the whole body, pumped from the heart to all over the body (*points at her body*). So, how does it [hormone] know where to go?
- 10 E: It could be just given to the appropriate vein.
- 11 T: But veins can reach everywhere in our body.
- 12 E: Perhaps, only the vein which goes to the target organ.
- 13 V: Maybe, there is protection in each vein.
- 14 T: (*glances at V and raises her eye brows*) Ayb?
- 15 Ayb: Teacher, I think this can happen through chemical messages conveyed between cells or cell groups.
- 16 T: Have I written here (*looking at the whiteboard*)? No, I haven't. OK now, there is a 'key-lock relationship'. You can consider the hormone as a key that can only open its target organ...

As the above shows, after Ezgi put forward a tentative idea, Mrs. Celin prompted her to think about her viewpoint by means of co-regulation processes. All these processes were aimed at assisting Ezgi in clarifying her thinking and achieving a better understanding of the issue. During this episode, supportive interpersonal

interactions were apparent in which the teacher created an inclusive space in the class by encouraging students to express their own points of view as well as her using non-judgemental language and tone by avoiding direct evaluative comments.

6.3.4 Using peer assessment

Incidents of metacognitive co-regulation were also identified, when the teacher used peer assessment for checking or discussing students' ideas during whole class activities. During these episodes, she encouraged them to share their own ideas and then requested an assessment of their understanding from the rest of the class. Co-regulation processes in these episodes had the function of stimulating the students to think about their ideas as well as alternative viewpoints, helping them clarify and elaborate upon each other's ideas, and enabling knowledge co-construction by linking a variety of ideas.

The next episode taken from an introductory activity of the topic of the 'nervous system' illustrates an example of this type of co-regulation process. Previous to this episode, the students were sharing their ideas in relation to the key concept, the 'neuron cell'. To start with, Mrs. Celin asks the students to explain the structure of the nervous system by using the 'cell and tissue systematic', which they have learn previously, and then asks Murat to share his idea with the class (turn 1 & 3). He presents his viewpoint of the issue inaccurately as well as expressing uncertainty (turn 4 & 6). Next, the teacher seeks further explanation with regard to his viewpoint (turn 7), but Murat does not add anything more to his explanation (turn 8). Then, after getting the class's attention, Mrs. Celin prompts all the students to reflect on Murat's idea by asking what they think about his explanation and whether they have any alternative viewpoints (turn 9). Next, after getting permission from his teacher, Vural presents a different explanation to that of Murat (turn 12 & 14). In the last turns, Mrs. Celin affirms Vural's idea and provides more elaboration together with other students.

Episode 6.5 – Introductory activity 2

- 1 T: OK, um, when thinking about the relationship between cell and tissue, how do you describe the structure of nervous system by using the

- cell-tissue systematic which you learnt last year (*standing and looking at whole class*)?
- 2 S: For the nervous system?
- 3 T: (*nodding*) Starting from the basic neuron cell to the top, from the simple towards the complex. Murat?
- 4 M: Teacher, I am not sure, but it must be neuron, nerves.
- 5 T: Nerves (*nodding and looking at Murat*).
- 6 M: Nervous tissues and skin (*expresses uncertainty*).
- 7 T: OK, anything else?
- 8 M: That's all.
- 9 T: OK, this is what Murat thinks (*rise in the volume of her voice*). Anyone who agrees with Murat or anyone who wants to explain it differently (*looks at whole class*)?
- 10 V: (*raising his hand*)
- 11 T: Vural?
- 12 V: Teacher, mine is different. I would say, neuron cells, nerve tissues, brain,
- 13 T: OK, brain (*nodding*),
- 14 V: and lastly nervous system and here we are (*smiles and shows his body*).
- 15 T: Yes, good! Neuron cells come together to constitute nerve tissue, nerve tissues come together to constitute organs, like the brain (*points at the diagram on the whiteboard*).
- 16 V: brain, spinal cord.
- 17 Mel: spinal bulb.
- 18 T: yes and when these organs come together, they constitute the nervous system.

In this episode, after Murat articulated his idea, the teacher requested an assessment of his understanding from his peers. By means of this co-regulation process, Murat and other students were prompted to reflect on his as well as their understanding of the topic. Moreover, Murat was provided with an indirect assessment of his idea when Mrs. Celin affirmed and elaborated upon Vural's explanation, which may have helped him clarify his thinking and construct new understanding. During this

episode, positive interpersonal interactions were visible in which the teacher encouraged the students to share their ideas freely and praised their answers. Also, the students and teacher showed mutual respect to one another by attentively listening and responding to each other's ideas.

6.3.5 Summary

The analysis has revealed that students' expression of a misconception, uncertainty or a lack of understanding about a scientific idea through a variety types of questions and statements led to the emergence of co-regulation episodes. This form of episode was also identified when the teacher attempted to check and discuss students' ideas with their peers. During these episodes, the students requested and/or received an assessment of their content understanding from the teacher or peers by articulating their perspectives and opinions to each other in both whole class and small group inquiry activities. In most cases, these co-regulation processes had the function of stimulating the students to reflect upon and clarify their thinking as well as facilitating the construction of new scientific understanding by enabling them to modify their initial conceptions.

Furthermore, the analysis of the students and teacher's verbal and nonverbal interactions showed evidence of a positive quality of interpersonal interaction in almost all the episodes of metacognitive co-regulation. For instance, in those involving the teacher and students, positive interpersonal interactions were evident in which the former regularly created an inclusive discussion space by encouraging the latter to share their points of view, praising their answers, and using non-judgmental language and tone. Moreover, in the episodes of student-student interactions, a positive social climate was always apparent where they appeared to be supportive and respectful of one another by making eye contact, attentively listening and constructively responding to each other's ideas within their group.

These findings indicate associations between the presence of a positive quality of interpersonal interactions and the emergence of metacognitive co-regulation processes. When closely scrutinising the episodes analysed above, it is possible to see that the positive interpersonal interactions among the students or between them and the teacher appeared to create a positive atmosphere, which encouraged and

made them feel comfortable in monitoring their peers' comprehension or requesting an assessment of their own understanding from their peers or the teacher through co-regulation processes.

6.4 Shared metacognitive regulation

This section explores the patterns in the emergence of shared metacognitive regulation during the small group inquiry science activities. To identify and illustrate how these processes arose as the students participated in small group activities, the episodes of shared regulation were qualitatively examined in detail. Four major themes emerged from the analysis of data show that shared metacognitive processes commonly emerged when the students (a) selected an approach for performing the group task, (b) experienced conflicting ideas, (c) expressed uncertainty or tentativeness concerning their ideas, or (d) sought consensus about a conceptual idea within the group (see Table 6.2). Moreover, as with the co-regulation episodes, the analysis of data provided evidence of positive interpersonal interactions in almost all of the shared metacognitive regulation episodes. These findings are discussed with the illustrative episodes.

Table 6.2 Frequency and percentages of the themes regarding the emergence of shared metacognitive regulation episodes across the student groups

Themes	Group A		Group B		Total	
	(F)	(%)	(F)	(%)	(F)	(%)
Selection of an approach for performing the group task	12	22.2	10	17.2	22	19.6
Experiencing conflicting ideas	8	14.8	4	6.8	12	10.7
Expressing uncertainty concerning the group's shared idea	3	5.5	5	8.6	8	7.1
Seeking consensus on a conceptual idea	6	11.1	6	10.3	12	10.7

Note: The frequencies and corresponding percentages are out of the total number of shared metacognitive episodes for that particular activity.

6.4.1 Selection of an approach for performing group tasks

Students engaged in shared metacognitive episodes when they selected an approach or procedure for performing a group task. During these episodes, the group members set shared goals, clarified conditions about the group task, or negotiated how to proceed with the activity. All these shared planning processes played an important role in facilitating the group process by building a shared understanding of the task among the members.

The following episode taken from the ‘*journey of food*’ small group activity exemplifies this type of shared planning process. Here, the groups are engaged in exploring the digestion process of the nutrients they chose by answering a set of inquiry questions. In this extract, group A attempts to figure out how to proceed with this group task. At the beginning, after Kutay and Leman reach a consensus on how many nutrients they will choose by addressing the inquiry questions (turns 1 to 4), Leman suggests a possible approach to perform the task by asking for her partners’ ideas about whether they should write a story about the journey of nutrients in the human body instead of answering each of the questions one by one for each nutrient (turn 5). However, Kutay expresses disagreement with Leman’s suggestion, arguing that writing a story for each question would be too difficult (turn 6). In response, Leman glances at Kutay and provides clarification for her idea, telling her partners that only one story would be necessary to answer all the questions (turn 7). Subsequently, Ayse and Kutay express agreement with Leman by praising her suggestion (turns 8 & 9) and all of them attempt to clarify what needs to be done in the light of the new approach they have decided to adopt (turns 10 to 13).

Episode 6.6 – Small group activity two (Group A)

- 1 L: The question, ‘*In which part of the digestive system are the chosen nutrients digested physically and chemically?*’ (reading).
- 2 K: Now, we are supposed to choose two nutrients (looking at his partners).
- 3 L: A nutrient (glances at Kutay).

- 4 K: Well, we will choose two (*points at the question paper*).
- 5 L: Sorry, OK, now worries. Now, we will write a story about the journey of these nutrients in our body and explain in which sections of the digestive system they are digested chemically as well as physically. So, should we write a story for this activity or explain everything separately (*looking at her partners*)?
- 6 K: I think it is better to write separately. Otherwise, it is going to be hard to write a story for each question (*points at the question paper*).
- 7 L: Actually, I meant to write only one story for all of the questions (*glances at Kutay*).
- 8 K: OK, this seems more logical now (*smiles*). But, we...
- 9 Ay: Yes, it would be good in my opinion too.
- 10 L: So, we will explain the journey of these nutrients in this story. We will find out where they are digested physically and chemically (*glances at her partners*).
- 11 Ay: If needed, we can also draw a figure here.
- 12 K: But, first we need to choose the nutrients (*glances at Ayse*).
- 13 L: Ok, Kutay, let's choose then (*smiles*).

As this dialogue illustrates, group A successfully reached a consensus on an approach to pursue in order to perform their collaborative task. That is, by means of reciprocal interactions the students explored each other's perceptions and made a joint decision on how to proceed with the group task, which all indicate shared planning processes. These processes promoted the ongoing activity by developing a shared purpose and understanding of the task among the members. Furthermore, there was evidence of supportive interpersonal interaction in this episode. For example, Kutay and Leman appeared to be respectful of one another in spite of a momentary disagreement in their ideas. Also, the group discussion was inclusive with all the members attentively listening to each other's perspectives and there being mutual participation. All these features of interpersonal interactions seemed to have facilitated the process of consensus building in terms of a joint plan within this group.

6.4.2 Experiencing conflicting ideas

Episodes of metacognitive shared regulation processes were also identified when the students experienced conflicting ideas or recognised discrepancies in their understanding during the small group activities. In these episodes, they negotiated shared understanding by challenging each other to clarify and justify their viewpoints. While most of these shared regulation processes had the function of helping group members build a consensus of shared understanding during the process of knowledge co-construction, in several instances, they slowed down the continuation of the ongoing group discussion.

The following episode coming from the '*football match*' small group activity exemplifies this type of shared regulation process. In this part of the activity, group B attempts to explore how the events identified in their observation of the video clip can occur in the footballer's body without interfering with each other. In turn 3, after Ezgi expresses a lack of understanding concerning the inquiry question, Vural seeks help from the teacher. However, Mrs. Celin does not provide any assistance, but rather tells the group to discuss the question with each other (turn 4). Then, after Vural encourages his group friends to find an answer within their group, Brus suggests an idea which Ezgi challenges by referring to another which they agreed on previously (turn 7). In response to her, Brus attempts to justify his idea (turn 8) and Vural presents his point of view on this issue (turn 9), but these explanations do not convince Ezgi, leading her to challenge them again to justify and clarify their perspectives (turn 10). At this point, Brus suggests his group reflect on their various perspectives (turn 11).

Subsequently, Brus verbalises one of their shared ideas from the previous discussion (turn 15) and Vural elaborates upon this idea by providing an additional explanation (turn 16), which Ezgi challenges by putting forward a contradictory idea (turn 17). In response, Vural rephrases his explanation to try to convince her of his view on the matter (turn 18), but Ezgi continues to express a disagreement and asks a question which stimulates him to reflect on his own perspective (turn 19). Then, Vural counterchallenges Ezgi with another question as well as attempting to provide a justification for his explanation (turn 20). However, Ezgi carries on disagreeing with

Vural's viewpoint by asking further questions (turn 21). At this point, while Vural seems to now accept Ezgi's perspective, he also attempts justify his standpoint by explaining his different interpretation of the inquiry question (turns 22 to 26). In response, Ezgi challenges Vural's understanding of the question and attempts to clarify what is being asked in the question by quizzing him with other prompting questions (turns 23 to 31). Towards the end of the episode, Vural and Ezgi appear to reach a consensus on their conceptual understanding.

(Prior to Episode 6.7)

- 1 B: Let's move to the last question. 'How do these events occur in our body without interfering each other?' (*reading*).
- 2 E: I don't know (*smiles*).
- 3 V: Teacher, we cannot answer the fifth question (*turning toward the teacher*).
- 4 T: Why don't you discuss with each other? I think you can find an answer (*smiles*).
- 5 V: OK, I think, we can find an answer to this question (*speaks with a rise in volume of his voice*).

Episode 6.7 – Small group activity three (Group B)

- 6 B: All of these events are different things.
- 7 E: But we said they are interdependent (*looking at each other*).
- 8 B: But their functions are so different.
- 9 V: I think, all of them carry out the same type of event, because the message goes from the brain to each part of the body (*using hand gestures*).
- 10 E: So? (*glances at Vural*)
- 11 B: Alright (*smiles*), let's think about this now.
- 12 E: OK.
- 13 V: OK.
- 14 E: I think this is becoming a little bit complex (*raising the eye brows*).
- 15 B: Now, they don't interfere with each other.
- 16 V: Yes (*nodding*), because they perform the same type of events.
- 17 E: Same events (*glances at Vural*)? No, all the events will be different.

- 18 V: Different? OK, so, let's say same type of tasks (*looking at Ezgi*).
- 19 E: No! Are sweating and moving the same thing?
- 20 V: It is not in that sense, Ezgi. Don't all of them do the same thing?
Like when you are hit, the message immediately goes to the brain and
then you feel the pain (*using hand gestures*).
- 21 E: Do you feel pain when you sweat? I think they are not all the same.
Are the nervous system and excretory system the same?
- 22 V: OK, but it (*the question*) asks only about nervous system,
- 23 E: No! It says how do these events occur in our body without interfering
with each other (*points at the question paper and looks at Vural*), which
means it isn't only the nervous system. Remember that we also wrote
about the excretory system too. So, the excretory and nervous systems
can work without interfering with each other. Why? Because they are
doing different things. The brain sends different commands for both of
them. That's what I mean. They are not all the same,
- 24 V: OK, but we have been saying this only for the nervous system.
- 25 E: But, (*shakes her head*) in this question, we are explaining for all of
them [all the systems].
- 26 V: Brus and I have been writing about each system separately. That's
why I said so.
- 27 E: But the question is about all of the events, and there are plenty of
events occurring in our body. Is sweating among these events? Yes, it is
(*nodding*).
- 28 V: OK, we are writing differently now (*speaks with a calm voice tone*).
- 29 E: How come?
- 30 V: We will write separately about the nervous system and the other
systems.
- 31 E: No, Vural. You are supposed to write about all of the systems
together.
- 32 V: Gosh, OK, we will combine them (*smiles*).

As this text reveals, after recognising conflicting ideas while co-constructing knowledge, group B negotiated its shared understanding. During this process, having articulated their thinking within the group, the students challenged each other to

justify and clarify their understanding by means of shared metacognitive processes. For instance, in turns 7 to 13, their statements indicate shared monitoring processes in which they prompted each other to check and assess their shared understanding. Similarly, the statements and questions in turns 17 to 27 also show shared regulation processes which aim to stimulate them to reflect on their viewpoints. By means of this symmetrical form of interaction, they probed each other's ideas to clarify and justify their thinking, which then helped them to reach mutual group understanding concerning the inquiry question.

In terms of the quality of interpersonal interaction, the above extract provides evidence of a positive and inclusive atmosphere. That is, as can be seen in this extract, the group members attentively listened and showed mutual respect to one another's ideas, in spite of their challenging and counterchallenging one another. Moreover, they responded to each other's ideas through constructive criticism, which appears to have sustained the group dialogue and their shared metacognitive processes.

This interpretation is also supported by the analysis from one of the stimulated-recall interviews with group B, where the students were asked to articulate what they were doing and thinking during their interaction and engagement with the group task during this episode. As the extract below shows, they were aware of each other's thinking and engaged in reciprocal and shared processes at the metacognitive level after realising that there were conflicting ideas within the group. In turns 2, 11, 12, 13 and 15, Ezgi and Vural describe how they challenged each other's ideas after being aware of the discrepancy with their own perspectives. In addition, in turns 22 and 24, Vural explains how he became convinced that Ezgi's viewpoint was correct

Stimulated-recall interview 6.1 – Group B

- 1 I: OK, what's happening here then? Let's start with you Ezgi. You say 'they are interdependent' here. What did you think at that moment?
- 2 E: Brus thought that they are all different. So I wanted to say that if they function without intervening each other, they must be interdependent.
- 3 I: OK, let's watch a little bit more.
- 4 All: (*watching*)

- 5 I: Why do you say 'complex', Ezgi?
- 6 E: Actually, it was becoming complex. We wrote the answer first, and then needed to revise it again.
- 7 I: Ok, would you like to watch from the beginning?
- 8 E+V: Yes, yes...
- 9 All: (*watching*)
- 10 I: Yes, OK? Let's start with Vural.
- 11 V: Actually, here firstly, I imagined a human body, organs and nerves etc. When pinpricking someone, I always think that I will feel a lot of pain, my finger will start bleeding, I will be stressed and also will sweat. Actually, when thinking about all these things together, I assumed that they would be interdependent to, and also have the same type of neural events.
- 12 E: Yes, but they are not same.
- 13 V: They aren't same, but these events develop depending on each other and follow the same neural action.
- 14 I: Ezgi, what did you say, here?
- 15 E: Here, I said that they are different but interrelated. Vural was claiming that everything was the same, but they aren't actually the same things. One is providing something, and the other one is doing a different thing.
- 16 I: Well, Vural?
- 17 V: Yes?
- 18 I: Let's watch the rest of this episode (*watching*)...
- 19 I: Here?
- 20 E: Now, here we were discussing.
- 21 I: Did you agree what Ezgi said (*to V*)?
- 22 V: After thinking a bit, I thought that Ezgi could be right on this issue.
- 23 I: Yes.
- 24 V: I first filtered what she said in my mind, and her idea seemed to work for me.
- 25 I: OK, thanks...

The next episode taken from the '*poisonous plant*' small group activity illustrates another example for this type of shared metacognitive regulation. In this episode,

group A aims to explore how neural transmission occurs during the events they identified in their observations. At the beginning, the group are sharing ideas about how the nervous system functions while a goalkeeper attempts to catch a ball and Kutay presents his view about which neurons are stimulated during this incident (turn 4). Next, Leman glances at Kutay and expresses disagreement with him by suggesting an opposing idea (turn 5). Subsequently, while the latter attempts to clarify his perspective (turn 6), the former insists on her claim and challenges him by asking for justification of his standpoint (turn 7). In response, Ayse and Kutay provide a rationale for their perspective (turns 8 and 9), but Leman remains unconvinced and asks them another question (turn 10). In response, Kutay stands up and elaborates upon their perspective by using his body language (turn 11), which Ayse affirms and builds on (turn 12). Next, following these elaborations, Leman remains silent, and Ayse asks her group to reflect on what they have been discussing (turn 14). Subsequently, Kutay paraphrases their joint idea and seeks agreement from his partners (turn 15). Then, Leman and Ayse express agreement with him and the group continues to share and co-elaborate upon their ideas (turn 16 to 20).

Episode 6.8 – Small group activity four (Group A)

- 1 Ay: The ball comes and he sees where the ball is going. Here (*pointing at the nervous system diagram*), the message goes to the brain and the brain responds through the nerves (*glances at her partners*).
- 2 L: The nerves go to the legs (*looking at the diagram*).
- 3 Ay: They stimulate the muscles.
- 4 K: I think it's like this. It [message] first comes from our eyes to the brain, then from the brain to the cerebellum (*explaining on the diagram*), the spinal bulb, the spinal cord and all of the neurons in the whole body.
- 5 L: OK, but it doesn't have to go to all of the neurons (*glances at K*).
- 6 K: It [message] needs to go to all of the neurons (*glances at L*), because he cannot know where the ball is going (*using hand gesture*).
- 7 L: It is enough if it only goes to the legs. Why should it also go to the hands (*raises her eye brows*)?
- 8 Ay: Because he is the goalkeeper.

- 9 K: Perhaps, he is going to react to the ball with his hands if it comes from up high (*using a hand gesture*).
- 10 L: Well, OK, but in the video, isn't the ball going to his feet (*looks at her partners*)?
- 11 K: Look, he gets into position like this in the middle of the goal (*stands up and uses body language*). So taking this position means that he is ready for everything (*speaks with a rise in the volume of his voice*).
- 12 Ay: Yes (*nodding*), that means the brain sends a message to everywhere in the body.
- 13 L: (*thinking without responding*)
- 14 Ay: Now, let's start from the beginning (*looks at her partners*).
- 15 K: OK, so it [neural message] is sent to the whole body by the brain and then when the ball comes, the relevant organ responds (*explaining by using the diagram*). Is that OK (*glances at his partners*)?
- 16 Ay: Yes (*nodding*).
- 17 L: Yes, then, he cannot keep the ball and the ball goes near the poisonous plant. When he touches the poisonous plant (*demonstrating on the diagram*)...
- 18 Ay: When touching...
- 19 L: When he touches it, the needle is broken.
- 20 Ay: Poisoned toxins make contact with his hand. So, he is stimulated here immediately (*glances at his partners*).

As this dialogue reveals, after experiencing conflicting ideas the students negotiated mutual group understanding which facilitated the knowledge co-construction process. During this process, the students shared ideas and prompted each other to justify and clarify their understanding, which is evidence of shared metacognitive processes. For example, in turns 5 to 12, after recognising there were conflicting ideas, the group members prompted each other to reflect on their ideas through statements and questions, which indicate shared monitoring processes. Furthermore, in turns 14 to 17, they checked and assessed their shared understanding, which also indicates a shared monitoring process. During these symmetrical interactions, they were able to build a consensus on a mutual understanding within their group which then sustained the knowledge co-construction process.

Furthermore, positive interpersonal interaction was also apparent in this episode, where the members of group A showed mutual respect and attentively listened to each other by making eye contact, paying close attention and responding to the ideas shared with a sense of mutual purpose. As was the case in the previous episode, the positive quality of the interpersonal interaction appeared to sustain the dialogue among the students and their shared metacognitive process.

6.4.3 Expressing uncertainty concerning a group's shared idea

Incidents of shared metacognitive processes were also identified when the students expressed uncertainty or tentativeness concerning their shared ideas and during these episodes they often prompted each other to reflect on their shared understanding. These shared regulation processes performed the function of helping them to clarify and revise their shared ideas while co-constructing knowledge within their group.

The following episode coming from the '*poisonous plant*' small group activity illustrates an example for this type of shared regulation process. In this episode, group B attempts to identify why the child pulled his hand away before he screamed when touching the poisonous plant by considering the process of neural transmission. At the beginning, after Brus reads the inquiry question, the students share and build on each other's ideas in order to produce a joint answer about how the neural transmission occurs during this incident (turns 1 to 10). After they appear to have reached a consensus, they decide to write down their shared explanation. At this point, Brus and Vural express uncertainty, which then stimulates the group to reflect on their shared understanding (turns 11 & 13). Subsequently, the students begin to co-elaborate and clarify what they have been discussing (turns 14 to 22). At the end of the episode, the group appear to have sustained their shared understanding.

(Prior to Episode 6.9)

- 1 Brus: 'In your opinion, what do you think what kind of relationship can exist between pulling his hand away before screaming and the message transmission in the nerves?' (*reading*).
- 2 V: Electrification happens (*points at the diagram*).
- 3 E: Which means the sensory neurons make the child pull his hand away (*all looking at each other*).

- 4 V: Sensory neurons feel, and then the impulse goes to the spinal cord.
5 E: Yes, it goes to the spinal cord through electrification.
6 V: The motor neurons cause him to pull his hand away.
7 E: It is a movement neuron (*glances at V*).
8 Brus: Then, the electrification stops and chemical transmission starts.
9 E: Sensory neurons (*writing*).
10 V: Can you say it aloud?

Episode 6.9 – Small group activity four (Group B)

- 11 Brus: Are you sure that this [explanation] is true (*speaks with an uncertain voice tone*)?
12 E: Yes.
13 V: Um kids, one second (*speaks with uncertain voice tone and facial expression*).
14 E: Look, it should be sensory neurons or what is your explanation? (*glances at her partners*) Nothing else comes to my mind.
15 Brus: (*Shrugs his shoulder*),
16 E: I think the sensory neuron receives [the stimulus]...
17 Brus: Um, OK, it receives the stimulus by means of electrification (*writing*).
18 E: Yeah, this one is accurate. Now, through electrification to the spinal cord.
19 V: The neurons in the spinal cord send the message to the motor neurons. And so, the motor neurons cause him to pull his hand away as a reflex (*explaining on the diagram*).
20 E: Yes (*nodding*), we will say that it makes him pull his hand away as a reflex.
21 V: Yes.
22 E: OK, finished now.

In this episode, group B was presented with opportunities to co-construct new knowledge by building on and discussing each other's ideas. As these interactions show, as a result of uncertainty expressed within the group, the students checked and assessed their mutual understanding, which indicates a shared regulation process. For

instance, their statements and non-verbal actions in turns 11 to 13 illustrate shared monitoring processes which stimulated them to reflect on their viewpoints. Furthermore, their statements in turns 14 to 22 also show a shared monitoring process in which they checked and assessed the group's shared understanding. Hence, by the means of these symmetrical interactions they were able to sustain knowledge co-construction through clarifying and revising their shared ideas.

Moreover, similar to other episodes, positive interpersonal interaction among the students was noticeable. For example, they actively listened to each other by making eye contact and attentively responding to ideas and sharing questions. The group also respected and valued each other's contribution which led to the creation of an inclusive space in which they were able to work cohesively. This, in turn, facilitated group interaction and the emergence of shared regulation processes.

6.4.4 Seeking consensus on a conceptual idea

Lastly, episodes of shared metacognitive regulation were identified when the group members sought consensus on a conceptual idea. During these episodes, they made their thinking visible by sharing ideas with each other and seeking agreement about a conceptual idea within the group. These shared regulation processes had the function of helping them to build agreement on a shared conceptual understanding which facilitated the process of knowledge co-construction.

The next episode taken from the '*water content of our body*' small group activity exemplifies this type of shared regulation process. In this part of the activity, the students aim to figure out how the ADH hormone is secreted in order to prevent water loss in the human body. At the commencement of this episode, after rephrasing the inquiry question, Brus clarifies some aspects of it in response to Ezgi's request (turns 1 to 3). Then, the latter asks for her partners' ideas concerning this inquiry question (turn 4) and the former briefly states his viewpoint (turn 5). Next, after Ezgi probes Brus' explanation (turn 6), he provides a detailed elaboration on his perspective (turn 7). At this point, Vural joins the dialogue and seeks a consensus about the idea put forward by Brus (turn 8), which stimulates the group to reflect on and negotiate their mutual thinking (turns 9 to 13). Towards the end of this episode, group B appears to reach an agreement on its mutual understanding.

Episode 6.10 – Small group activity five (Group B)

- 1 B: It [inquiry question] is asking how it is secreted and how water loss in the blood is prevented by the body (*looking at his partners*).
- 2 E: Blood (*glances at B*)?
- 3 B: Yes, since the water and waste materials are included in the blood (*glances at E*).
- 4 E: OK, so, how is this perceived?
- 5 B: The kidneys can say.
- 6 E: But, how can it be perceived?
- 7 B: The kidneys can say that I have sent a lot of urine to the bladder, it may be full now. And then it sends a signal to the brain, OK? (*explaining on the diagram*) The brain informs the hypothalamus, and the hypothalamus tells the pituitary gland to secrete ADH in order to respond to the kidneys' request. So ADH gets into the vessel and goes and solves the problem.
- 8 V: So, now, should we say that the kidneys send signals to the brain (*glances at his partners*)?
- 9 E: Sending signals to the brain?
- 10 V: Yes and the body prevents water loss by secreting ADH hormone.
- 11 E: Yeah possible (*nodding*). Anyway, it is the one responsible for balancing the water level.
- 12 V: Yes, balancing.
- 13 B: Alright. So, how much time have we got left?

In this episode, while the students were articulating and sharing perspectives with each other, Vural sought a consensus on their shared ideas, which led to them negotiating their shared understanding. During this process, they confirmed and clarified their understanding through shared regulation processes which facilitated the process of knowledge co-construction. For example, their questions in turns 8 and 9 indicate a shared monitoring process which prompted them to rethink their ideas. Moreover, their statements in turns 9 to 13 also show shared monitoring processes in which they confirmed and clarified their shared understanding. Similar to other shared regulation episodes, these symmetrical interactions occurred in a

positive and inclusive atmosphere in which the group valued and respected each other by attentively listening and responding to ideas and sharing questions.

6.4.5 Summary

As illustrated in the above sections, shared metacognitive regulation commonly emerged when the students selected an approach for performing a group task, expressed uncertainty concerning their shared ideas, experienced conflicting ideas, or sought consensus about a conceptual idea within their group. Moreover, in these episodes, by making their thinking explicit through metacognitive statements and questions, they negotiated their shared understanding. These shared regulation processes had the function of helping them to build a consensus on an approach to pursue for performing their joint tasks, clarify and justify their ideas, and achieve a mutual understanding within their group through refining each other's ideas.

This finding provides some evidence for the recent debate in the literature with regard to the distinction between shared metacognitive regulation and the co-construction of knowledge processes during group work (see Hadwin *et al.*, 2011; Pino-Pasternak & Whitebread, 2011; Volet *et al.*, 2009b). That is, as shown in most of the episodes above, shared regulation processes mostly facilitated and simultaneously occurred during the co-construction of understanding within the student groups. In particular, shared monitoring processes played an important role in sustaining the ongoing co-construction of understanding by enabling a continual co-elaboration and expansion of ideas during group work.

In addition, the analysis of the students' verbal and nonverbal interactions provided evidence of a positive quality of interpersonal interactions in almost in all the shared regulation episodes, with the groups having a supportive and respectful relationship with one another by making eye contact, attentively listening and constructively responding to each other's ideas, as well as creating an inclusive space for discussion and group cohesion. Similar to the co-regulation episodes, the positive nature of the interpersonal interactions among the students seemed to play an important role in the emergence of shared metacognitive processes. For instance, the inclusive and cohesive nature of the groups facilitated them in building a shared understanding of the inquiry task as well as in producing a joint plan to pursue. Furthermore, by means

of showing mutual respect and attentively listening to each other, the group members appeared to be confident in articulating ideas and monitoring or negotiating their mutual understanding. Finally, even in cases of the emergence of conflicting ideas within a group, the positive aspects of its members' verbal and nonverbal interactions seemed to sustain the ongoing dialogue as well as the shared regulation processes.

6.5 Chapter summary

This chapter has addressed the third research question which sought to investigate when and how social forms of metacognitive regulation manifest, and how they influence students' learning as they participate in scientific inquiry learning activities. As the themes identified in this analysis show, by using different types of metacognitive statements and questions, the focal students engaged in co-regulation and shared regulation of metacognitive processes in a variety of learning situations, all of which influenced their learning in various ways. Furthermore, the quality of the interpersonal interactions was examined for the social forms of metacognitive regulation episodes, and evidence of positive interpersonal interactions was present in almost all of the episodes. Moreover, the analysis revealed that the presence of a positive quality of interpersonal interactions created a positive atmosphere which appeared to facilitate the emergence of social forms of metacognitive regulation processes. The next chapter contains discussion and reflection on the key findings that have emerged from the three analysis chapters as well as their implications for practice and future fruitful research avenues.

Chapter 7 – Discussion and Conclusion

7.1 Introduction

The aim of this thesis has been to investigate how Turkish upper primary students (aged 12, grade 7) regulate metacognitive, motivational and emotional aspects of their learning during scientific inquiry learning activities. As discussed in Chapter 2, although social aspects of regulation of learning have been a recent focus in the research literature, little is known about how students engage in self and social forms of regulation processes in social learning situations. In particular, there is a lack of empirical research investigating the occurrence of self-, co-, and shared regulation of metacognitive, motivational and emotional processes simultaneously during students' engagement in scientific inquiry activities and a complete absence in the Turkish primary school context.

In addressing these gaps, as explained in detail below, this current study makes a number of contributions to the existing literature. Firstly, it provides an in-depth examination of self-, co-, and shared regulation of metacognitive, emotional and motivational processes used by upper primary students during scientific inquiry activities. Moreover, it provides evidence about how students' regulation of their learning processes changes over time across a sequence of scientific inquiry activities as well as across student groups. Furthermore, it enriches our understanding of how social forms of regulation processes emerge and influence students' learning in the context of whole class and small group scientific inquiry activities.

In this final chapter, firstly, the key findings of this study are summarised and discussed in order to address the research questions of this thesis (Section 7.2). Next, after considering the theoretical and the methodological contributions (Sub-sections 7.2.4 & 7.2.5) and limitations of the research (Section 7.3), its practical implications are presented as well as proposals being made regarding potentially fruitful future directions for further enquiry (Sections 7.4 & 7.5).

7.2 Discussion of the findings and contributions of this study

This section contains a summary and discussion of the key contributions of this thesis in relation to the extant literature in terms of its findings and the methodology employed.

7.2.1 RQ1: Do students use self-, co-, and shared regulation of metacognitive, motivational and emotional processes during scientific inquiry activities, and if so, what relationship exists between the types of these regulation processes?

The analyses carried out in Chapter 4 have shown that the Turkish upper primary students engaged in specific processes of self-, co-, and shared metacognitive, motivational and emotional regulation in the context of scientific inquiry activities. These findings extend the previous research, which has mostly focused on self or social regulation of learning independently (Hurme *et al.*, 2009; Iiskala *et al.*, 2011; Järvelä & Järvenoja, 2011; Molenaar *et al.* 2010; Volet *et al.* 2009b), by providing a detailed characterisation of self-, co-, and shared regulation of metacognitive, motivational and emotional processes used by upper primary students during scientific inquiry learning activities.

One of the main results of this study was the discovery that the focal students actively regulated various aspects of their learning through engaging in asymmetrical and symmetrical interactions during the scientific inquiry tasks in naturalistic contexts. Moreover, the emergence of the types of these regulation processes was found to be associated with the types of instructional activities and pedagogical interactions. More specifically, in addition to revealing the processes indicative of self-regulatory metacognition which are commonly focused on individual students' content understanding, the findings have provided evidence of co-regulatory planning and monitoring processes during a variety of brief asymmetrical interactions (see Section 4.2). During planning processes, the students always received assistance from their teacher in relation to either the procedural aspects of the inquiry task or the understanding of task goals. Regarding co-regulatory monitoring processes, the teacher or students supported others in monitoring their understanding of the task content. The co-regulatory processes with the teacher

mainly took place in the introductory and whole class discussion activities, which mostly involved teacher-led interactions, whilst co-regulatory processes among students were only observed during their engagement in collaborative group work.

Furthermore, the results showed evidence of planning, monitoring and evaluation processes which were shared among multiple group members via symmetrical forms of interactions (see Section 4.2). In the shared planning processes, group members focused on the understanding of shared goals or the procedural aspects of the group task, all of which helped them to build a consensus on an approach to pursue for performing their joint tasks. The students also engaged in shared monitoring processes that mainly focused on the group's content understanding or joint task performance. Regarding evaluation processes, the students always reviewed their group's overall understanding of the scientific inquiry tasks. Moreover, all the shared regulation processes occurred during the small group collaborative activities which mostly involved collaborative reciprocal and symmetrical interactions among the students. During these regulation processes, the students made their thinking explicit, took into consideration each other's perspectives, as well as negotiating the group's mutual understanding via elaborations, justifications and questions.

In addition, besides engaging in individual monitoring and control processes in which they focused on either motivational or socioemotional aspects of their own learning, the students showed evidence of co-regulatory control processes in which the teacher provided support mostly in terms of motivational aspects of their learning during the whole class and small group activities (see Subsection 4.3.2). Moreover, the student groups engaged in shared monitoring and control processes collectively with a focus on both the motivational and socioemotional aspects of group learning by using a variety of strategies, which included, such as promoting a sense of tolerance and respect for the different viewpoints put forward, and giving compliments to one another (see Subsection 4.3.3).

Additionally, it emerged that self and social forms of emotional and motivational regulation processes played a critical role in these upper primary students' engagement with both the small group and whole class inquiry activities. More specifically, co-regulatory control processes with the teacher were observed to help them maintain successful engagement with the inquiry tasks as well as to contribute

positively to the social climate of the classroom. Also, shared monitoring and control processes were identified as crucial for effective group functioning. For instance, as illustrated in Subsection 4.3, there were several occasions where overcoming emotional and motivational challenges arising during small group activities was important for groups A and B to sustain reciprocal interactions among each other, increase group cohesion as well as shaping and constructing a positive socioemotional atmosphere in the groups. These findings extend the previous research which has been mostly carried out with samples of university students (Järvenoja & Järvelä, 2009; Järvelä *et al.*, 2008b), by revealing the importance of self and social forms of motivational and emotional regulation processes being utilised by younger students so as to create and sustain a positive social climate in the context of scientific inquiry activities.

Moreover, the outcomes of this research have revealed evidence of interplay between the different types of regulation processes, which help to shed light on the theoretical argument in the literature regarding how self and social forms of regulation processes are interrelated and influential in students' engagement in social learning situations (see Järvelä *et al.*, 2010; Volet *et al.*, 2009a). Regarding this, three types of interplay have emerged from the analysis of the data (see Section 4.5). Firstly, shared metacognitive planning and monitoring processes appeared to be influenced by one another. That is, in most of the observed cases it transpired that shared planning processes played a critical role in building a shared understanding of the task goals among group members and these set the scene for the subsequent shared monitoring processes. In a similar way, the information provided by shared monitoring of content understanding or task performance was often influential in changing or constructing a new joint plan for the group tasks.

Secondly, a different type of interplay was also identified between self and shared forms of emotional and motivational regulation processes. More specifically, in several instances, a group member's use of self-regulatory monitoring and/or control processes focusing on a socioemotional aspect of his/her learning appeared to activate a negative emotional response within the group, which then resulted in it engaging in shared control processes. Lastly, as illustrated in Section 4.5, the results have provided evidence of there being an overlap and interplay between

metacognitive and motivational and emotional regulation processes. In some cases, metacognitive monitoring processes occurred concurrently with and appeared to trigger those of emotional and motivational regulation. In particular, co and shared monitoring of content understanding sometimes led to the emergence of emotional or motivational experiences, which then necessitated their regulation.

Overall, these findings have provided in-depth insight into how different types of self and social forms of regulation processes influenced and interacted with one another during the scientific inquiry learning of upper primary students, and thereby has extended the previous research which has focused mostly on metacognitive, emotional or motivational aspect of self and social regulation processes in isolation (e.g., Iiskala *et al.* 2011; Järvelä *et al.* 2008b; Molenaar *et al.* 2010).

7.2.2 RQ2: How does students' use of regulation of learning processes change over time across the sequence of whole class and small group activities?

The analyses carried out in Chapter 5 have revealed salient differences in the patterns of students' use of regulation processes over time across the sequence of scientific inquiry activities as well as across and within groups A and B. These findings advance our understanding of how younger students' use of self and social forms of regulation processes changes during the course of a scientific inquiry unit, and can be compared with the previous research which has mostly studied the changes in university students' regulation of learning over time in collaborative learning situations (e.g., Hurme *et al.* 2009; Järvenoja & Järvelä, 2009; Volet *et al.*, 2009b).

Firstly, in terms of changes in the use of metacognitive regulation, while there was no clear evolution for the whole class activities, groups A and B engaged progressively in more individual and shared regulation processes chronologically along the sequence of small group activities (see Section 5.4). More specifically, the findings suggest that the patterns of regulatory interactions remained mostly asymmetrical during the introductory activities and whole class discussions over time, while the group members interacted with each other increasingly in a more reciprocal and symmetrical way in terms of regulating their joint activity. This increasing use of shared regulation processes in which the groups interacted in a

mutual way can be explained by the difficulty level of the group tasks students undertook, which became progressively more complex towards the end of the scientific inquiry unit. The previous research supports this speculation with some evidence that metacognitive processes tend to emerge more frequently in cognitively challenging, complex learning tasks rather than with easy or extremely difficult ones (Iiskala *et al.* 2011; Perry *et al.*, 2002, 2006; Vauras *et al.*, 2003). As discussed in Section 5.4.1, this revelation can also be associated with the developing understanding of ground rules which the teacher continually strove to establish through emphasising the shared responsibility and active participation of all students for the small group inquiry activities. That is, this could have promoted the groups engaging in more symmetrical and reciprocal interactions, which are usually seen as a prerequisite for shared regulation processes (see Hadwin *et al.*, 2011; Hurme *et al.* 2009). In addition, the favourable social climate created within each group over time could be another reason for this increase, for as the analysis reported in Chapter 6 elicited, positive interpersonal interactions, which helped in establishing a supportive social climate within the groups, also appeared to promote and facilitate the emergence of shared metacognitive regulation processes.

Secondly, the rates of self and shared emotional and motivational regulation processes engaged in by the groups A and B showed an increasing trend along the time ordered sequence of the small group activities. This finding indicates that there were greater numbers of emotional and motivational challenges experienced by the student groups across these tasks over time. A possible explanation for this result relates to the characteristics of these activities, such as the level of task difficulty, as the students had more difficult group tasks towards the last sessions, which could stimulate negative emotions or low levels of motivation among them. This outcome can be also explained by the changing nature of group dynamics over time, which could have an influence on how the students interacted as a group. The results of a recent study carried out with a sample of university students (Järvenoja & Järvelä, 2009) support this claim suggesting that intrinsic group dynamics is one of the potential sources of emotional and motivational challenges that students experience in collaborative learning situations. Nevertheless, achieving a comprehensive understanding of how emotional and motivational challenges that younger students

experience can be associated with the group dynamics and its changing nature would require further study.

Thirdly, the findings show slightly different patterns of change in the rates of self and social forms of regulation processes for each student group as well as for each individual group member over time along the sequence of small group activities. For instance, as described in Section 5.4.1, concerning metacognitive regulation, the students in group A used more self-regulatory monitoring and co-regulatory monitoring processes among each other than group B. In addition, shared evaluation processes were used only by the former, whilst the trend observed for the members of the latter was a chronological increase in shared planning processes. In terms of within group differences (see Section 5.4.2), for example in group A, Kutay and Leman had higher rates of co-regulatory metacognitive monitoring processes than Ayse, and that student did not engage in any individual emotional and motivational regulation processes.

Group profiles elicited during the student interviews appeared to explain some of these intergroup and within group differences. More specifically, the nature of interpersonal relationship existing within the groups A and B appeared to be linked to some of the intergroup differences. For example, the analysis of data showed that group A engaged in more self and shared regulation processes, in which they expressed awareness of and controlled negative emotional experiences, than group B. As pointed out earlier, this finding can be associated with the higher quality of interpersonal relationships among the members of group B, in terms of a higher level of perceived emotional and academic peer support as well as stronger friendship ties among the group members, which could lead to this group encountering fewer negative emotional challenges while working collaboratively.

With regards to the within group differences, the nature of the interpersonal relationships also provides some possible explanations. For instance, in group A, Leman and Ayse engaged in more shared metacognitive regulation processes than Kutay, and the lattermost had the highest rates of emotional and motivational regulation in which he mostly expressed awareness of and controlled his negative emotions aroused through social interaction with his partners. These findings can be attributed to the stronger friendship or higher level of perceived emotional and

academic peer support between Ayse and Leman, which could explain why Kutay exhibited lower participation in shared metacognitive regulation processes as well as his having the highest rates of emotional and motivational self-regulation processes. Furthermore, this finding could be owing to some of the individual level characteristics, such as the students' social goals or perception of the role of group work, as Kutay was less positive and uncertain about the group work than his partners who had stronger positive feelings towards it as well as reporting more social advantages of engaging with such work.

7.2.3 RQ3: How do social forms of metacognitive regulation episodes emerge and function in scientific inquiry activities?

The results of this study in Chapter 6 have provided insight into the emergence and functions of co-regulation and shared regulation of metacognitive processes in scientific inquiry activities. These findings extend the previous research which has paid little attention to how social forms of metacognitive regulation processes emerge and in which ways they influence students' solo and joint learning, particularly in the context of whole class and small group scientific inquiry activities at the upper primary school level.

As described earlier, the students' expression of a misconception or uncertainty or a lack of understanding about a scientific idea through a variety of questions and statements often led to the emergence of co-regulatory monitoring processes, in which the students requested and/or received an assessment of their content understanding from the teacher or peers in both the whole class and small group inquiry activities. This form of episode was also identified when the teacher attempted to check and discuss an individual student's idea with his/her peers. In most cases, these co-regulation processes were identified as having the function of stimulating students to elaborate and reflect upon their thinking as well as facilitating the construction of a new scientific understanding by enabling them to modify their initial ideas.

Moreover, in terms of shared regulation (see Section 6.4), the analysis showed that seeking consensus about a conceptual idea through direct or implied questioning often led to the emergence of shared monitoring processes. Also in some cases, a

group member's explanation or question which conveyed uncertainty about a shared idea triggered the group members to check and assess their mutual understanding. Further, experiencing discrepancies with regard to each other's ideas was also observed to initiate shared monitoring processes in which the group members challenged each other's thinking via elaborations, justifications and questions. In addition, in this analysis, these shared regulation processes commonly appeared to facilitate and sustain the meaningful collaborative interactions within the group by helping its members build a consensus on mutual understanding, but they also inhibited the ongoing group discussion in a few instances. This finding concurs with the study of Iiskala *et al.* (2011), who identified the function of socially shared metacognitive regulation as either facilitating or inhibiting dyads' (aged 10) collaborative mathematical problem-solving processes.

These results can be compared with the previous research literature in relation to several aspects. Firstly, in line with the findings from recent work carried out with university students (Volet *et al.*, 2009b), this study points out the important role played by the questions and statements used by the upper primary students and their teacher in initiating and sustaining social forms of regulation processes. Secondly, it also extends the previous science education research, which has mostly investigated the role of questioning approaches in promoting productive discourse and co-construction of knowledge in science classrooms (e.g., Chin & Osborne, 2010; Hmelo-Silver & Barrows, 2008), by providing evidence regarding the potential connections between teacher and student questioning and the emergence of social forms of metacognitive regulation processes during both whole class and small group scientific inquiry activities.

The findings presented in Chapter 6 also indicated that there are links between the positive quality of interpersonal interactions and the emergence of social forms of metacognitive regulation processes. That is, in this analysis, co-regulation episodes between the teacher and students almost invariably involved positive and supportive interpersonal interactions in which the former appeared to create an inclusive discussion space by encouraging the students to share their points of view, listening to and taking into account their ideas, and using non-judgmental language and tone (see Section 6.3). In addition, evidence of positive interpersonal interactions was

visible in co-regulation and shared regulation episodes among the students in which they regularly appeared to be supportive and respectful towards one another by making eye contact, attentively listening and constructively responding to each other's ideas, as well as creating an inclusive space for discussion, whereby they were able to work as a cohesive group (see Sections 6.4 & 6.3).

This presence of a positive quality of interpersonal interactions was observed to create a favourable social climate, which, in turn, seemed to facilitate the emergence of co-regulation and shared regulation processes. For instance, the presence of mutual support and respect appeared to make the students feel comfortable monitoring their peers' comprehension or requesting an assessment of their own understanding from them or the teacher. Also, showing mutual respect, attentively listening and responding to one another created a positive group atmosphere which supported the students in planning their tasks, articulating their ideas as well as monitoring and negotiating their mutual understanding. Even in the cases with the emergence of conflicting ideas within a group, its inclusive and cohesive nature appeared to sustain the ongoing dialogue as well as the regulation processes among the students.

While the previous research has suggested that there are links between the quality of interactions and effective group functioning (e.g., Barron, 2003; Kempler & Linnenbrink, 2006), there has been a scarcity of enquiry into the role played by the quality of interpersonal interactions in social forms of regulation processes. One exception to this is a recent study conducted in the US by Rogat and Linnenbrink-Garcia (2011), who identified positive socioemotional interactions as facilitating a high quality of social regulation processes of upper elementary students during small group mathematics tasks. This current thesis research builds on this line of investigation by showing how the quality of interpersonal interactions influence the emergence of social forms of metacognitive regulation processes engaged in by the upper primary students during both whole class and small group scientific inquiry activities.

7.2.4 Theoretical contributions

The results of this thesis present a number of contributions to the knowledge which can inform and advance the existing theoretical perspectives of self and social regulation of learning.

Firstly, as explained in Chapter 2, while most of the SRL models assume different types of self-regulatory processes interacting with and influencing each other (Boekaerts, 2011; Meyer & Turner, 2006; Pintrich, 2004), and the previous research presents mainly quantitative evidence about the relationship among different aspects of students' self-regulation processes (Chauncey & Azevedo, 2010; Wolters & Benzon, 2013), there has been a lack of empirical and conceptual understanding of how self and social forms of regulation processes can be related to one another (Butler, 2011; Hadwin *et al.*, 2011; Perry & Winne, 2013; Volet *et al.*, 2009a). The current study contributes to this research gap by identifying several types of interplay and interactions among different types of regulatory processes. In particular, this study shows that self-, co-, and shared metacognitive and motivational and emotional regulation processes can sometimes occur simultaneously or subsequently, and interact with and influence one another. These results offer insightful information which can assist the development of conceptual models and frameworks which clearly describe the concurrent and reciprocal nature of self and social forms of regulation processes.

Moreover, as stated in Chapter 2, while the existing literature describes the current conceptualisations on social regulation of learning and highlights its importance for the success of students' learning, there has been a limited understanding in relation to the emergence and roles of social forms of regulation processes in actual learning situations (Hadwin *et al.*, 2011; Iiskala *et al.*, 2011; Järvelä *et al.*, 2010; Vauras & Volet, 2013; Winne *et al.*, 2013). Considering this gap, as explained in detail in Sections 7.2.1 and 7.2.3, this thesis extends our understanding by identifying how co-regulation and shared regulation of metacognitive, motivational and emotional processes are activated and in which ways they can influence students' engagement in scientific inquiry activities. These findings can be used to inform the current

conceptual perspectives attempting to describe the mechanisms by which social forms of regulation processes can occur and function in social learning situations.

These results also provide insight into the recent debate in the literature with regard to the distinction between social regulation processes and co-construction of knowledge in collaborative learning situations (Rogat & Linnenbrink-Garcia, 2011; Volet *et al.*, 2013). Concerning this issue, in this current thesis, it has been observed that some of the shared metacognitive regulation processes occurred simultaneously during and had a function of facilitating the co-construction of knowledge in scientific inquiry activities. In particular, it was observed that shared monitoring processes directly played a key role in sustaining the ongoing co-construction of understanding by enabling a continual co-elaboration, justification and expansion of ideas, while shared planning processes appeared to have an indirect influence by building a shared understanding of the task which facilitated the meaningful interaction towards the co-construction of knowledge within the student groups.

The present study also suggests considering the quality of interpersonal relationship and interactions among individuals in the conceptual models and frameworks when explaining the mechanism for social forms of regulation processes. In the extant literature, only a few researchers have considered the interpersonal aspects of students' learning in relation to social forms of regulation processes (Rogat & Linnenbrink-Garcia, 2011; Salonen *et al.*, 2005; Vauras *et al.*, 2008). For instance, Salonen *et al.* (2005) suggested that co-regulation occurring among peers in a small group learning situation involves partners' interpersonal relational control processes besides metacognitive, affective and motivational ones. In their analysis of two fourth grade high-achieving students' joint problem-solving process, Salonen and his colleagues identified interpersonal relational control processes as being operative, which could facilitate or inhibit the effectiveness of metacognitive co-regulation processes between the interacting partners. Also, as explained previously, Rogat and Linnenbrink-Garcia (2011) presented evidence in relation to the role played by the positive socioemotional interactions among upper elementary students in facilitating a high quality of social regulation processes during small group mathematics tasks. As shown in Sections 7.2.2 and 7.2.3, the quality of interpersonal relationship and interactions appeared to be associated with the emergence of co-regulation and

shared regulation processes. Particularly, the presence of positive quality of interpersonal interactions was observed to create a favourable social climate, which, in turn, seemed to facilitate the emergence of, and sustain co-regulation and shared regulation processes among participants. Also, the quality of interpersonal relationship existing within the student groups appeared to be linked to some of the intergroup and within group differences in terms of the use of self and social forms of regulation processes. Considering these findings, the current study calls attention to the importance of taking into account the quality of interpersonal relationship and interactions among individuals in the study of self and social regulation processes.

This thesis also contributes to the recent discussion of how students' self and social forms of regulation processes change and evolve over time in social learning situations (Chan, 2012; Perry & Winne, 2013; Volet *et al.*, 2009b; Zimmerman, 2008). As mentioned in Chapter 2, while the recent research focus has been to examine regulation of learning as a dynamic and developing process within real time and contexts, there has been a lack of empirical and theoretical understanding of how students' use of regulation processes could change over time across multiple learning activities. In addressing this issue, the current study identifies that student groups' use of self and shared regulation processes showed an increasing trend over time along the sequence of small group activities, and these increases appeared to be associated with several factors, such as including the task difficulty level, ground rules for group work, and presence of positive social climate within student groups.

Lastly, the present study provides insight into the recent discussion about the universal application of regulation of learning theory (McInerney, 2011; Nota *et al.*, 2004; Shi *et al.*, 2013). As mentioned earlier, the theoretical models of regulation of learning have been developed and extensively researched mainly in Western countries, while there has been a lack of empirical research in other contexts, in particular in Turkey. In the existing literature hence, it is usually questioned whether the conceptual perspectives on self and social regulation of learning can have a cross-cultural applicability (McInerney, 2011). Concerning this issue, this study support the universality of regulation of learning theory by offering qualitative evidence that Turkish upper primary school students (12 years old) can engage in various types of self-, co-, and shared metacognitive, motivational and emotional regulation as a

dynamic and constantly unfolding process over time during scientific inquiry learning activities similar to their counterparts in Western and other contexts.

7.2.5 Methodological contributions

The design and analyses of this research have taken into account a number of suggestions and gaps stated in the literature. In this regard, previously, researchers have pointed out the need for studies conducted in a naturalistic classroom setting with younger students (Butler, 2011; Perry, 1998; Perry & Rahim, 2011; Whitebread *et al.*, 2009), assessing regulation of learning as an event through using process measures (Boekaerts & Cascallar, 2006; Butler, 2011; Järvelä *et al.*, 2010; Winne & Perry, 2000; Zimmerman, 2011), and utilising multiple sources of data (Azevedo & Strain, 2011; Perry *et al.*, 2002; Schutz *et al.* 2006; Veenman, 2005). In line with these proposals, the current study has made a contribution to the regulation of learning research by exploring upper primary students' self and social forms of regulation processes in a naturalistic whole class and small group scientific inquiry learning setting over time through utilising data from classroom video observations, stimulated-recall group interviews, semi-structured interviews, informal interviews and documentation.

In this study, besides providing concurrent measurement of regulation processes in real time and real context, the analysis of the classroom video observational data was successful in terms of identifying verbal and nonverbal (e.g., facial expressions, vocalization and specific body language gestures) behaviours of students and their teacher indicating evidence of self and social forms of metacognitive, emotional and motivational regulation processes (Boekaerts & Cascallar, 2006; Whitebread *et al.*, 2009). This data collection tool was particularly useful for gaining an understanding the interactions and interplay between self and social forms of metacognitive and motivational and emotional regulation processes, while they were engaging in scientific inquiry activities. Moreover, since the video recordings of learning activities in a natural classroom setting enabled the analysis of data in relation to the social context, it was possible to obtain clear descriptions of the contextual aspects of the scientific inquiry activities. This made it possible to provide insight into how social forms of metacognitive regulation processes emerged and functioned, and how

students' emotional and motivational states were challenged as well as regulated both individually and/or socially.

Furthermore, the students' interpretations and appraisals explicated during the group stimulated-recall interviews supported and facilitated the analysis and interpretation of some of the observational data by providing important insights into unobservable aspects of the students' interactions and actions during the small group inquiry activities. For example, during these interviews, the students were able to articulate and describe their individual as well as their group's thinking at the metacognitive level. Moreover, they were able to explain why and how they felt when facing emotional and motivational experiences, as well as how they attempted to control these individually and socially in order to maintain engagement with the task. In this study, it was also demonstrated that using video episodes as stimuli is effective in prompting recall about students' metacognitive, emotional and motivational experiences. Also, conducting stimulated-recall interviews in groups can facilitate both individual and collective reflections, thereby obtaining multiple accounts and perspectives from the students themselves about their specific learning experiences. In sum, the analysis of the stimulated-recall group interview data in this study has proved to be successful for eliciting individual and group interpretations and appraisals of their observed behaviours, thus providing interpretation validity for the analysis of observational data.

Moreover, in line with the claims of other researchers (e.g., Hurme *et al.*, 2009; Iiskala *et al.*, 2011), it became clear that the use of both individual and group levels of analyses was needed in order to provide a more complete picture of students' social regulation of learning processes during both whole class and small group scientific inquiry activities than were it otherwise. This extends the previous research which has mostly focused solely on the individual as the unit of analysis when studying metacognition, emotions or motivation in the context of science learning situations (e.g., Azevedo *et al.*, 2004; Greene & Azevedo, 2009; Manlove *et al.* 2006; Sperling *et al.*, 2004; Vollmeyer & Rheinberg, 2006).

Finally, utilising both qualitative and quantitative analyses techniques in this study has allowed for the examination of students' regulation of learning in a variety of ways as well as having assisted the triangulation of observational and interview data. For

example, in addition to the triangulation of the video and stimulated-recall group interview data in the measurement of regulation processes, the semi-structured interviews data allowed for the creation of profiles for groups A and B, which facilitated the interpretation of the qualitative and quantitative analyses of the students' regulation processes. Moreover, it emerged from the analysis and the findings that different data sources were essential for providing details of the complexity of scientific inquiry learning situations.

7.3 Limitations of the study

In order to address the research questions of this study, a variety of data was collected and a range of analysis techniques were utilised. However, some limitations emerged with regard to the research design and analysis which need to be taken into consideration when interpreting the findings and contributions.

Firstly, by focusing on two groups of three students and their science teacher across the sequence of scientific inquiry activities over time, I obtained a detailed set of data which allowed for an in-depth analysis of upper primary students' self and social forms of regulation of learning processes. However, it should be also noted that because of the qualitative nature of this study, the analysis of regulation processes may have been influenced by my subjective opinion regarding these processes, as I was the only researcher who carried out the analysis of the data sets. Nevertheless, as mentioned in Section 3.7, in order to make certain that the interpretations and findings correctly reflected students' inquiry learning experiences, I put aside my preconceived notions about the regulation of learning theory and remained open-minded paying great attention not to let any of my personal beliefs and assumptions have an impact on any part of the research process. Also, the analysis process was subject to verification through the literature, interactions and discussions with my supervisors, fellow students and other informed people in the field that I met at conferences and seminars. In addition, detailed information was provided concerning the data collection, coding and analysis processes with the purpose of ensuring that the research process was adequately transparent for the readers. An acceptable level of inter-coder reliability was also achieved in order to ascertain that the coding and analysis processes were being performed reliably (see Section 3.6.1 for details).

Moreover, the triangulation of data sources and analysis techniques served to enhance the veracity of this research.

Another limitation was that the sample size of this study was relatively small, with only one science teacher and two student groups (A and B) as representatives of their classroom being recruited from a primary school in Turkey. This due to several reasons, such as, difficulties in accessing schools as an external researcher wishing to conduct video-based research in relation to the field of educational psychology as well as the problems around obtaining consent from the participants. Accordingly, it was not possible to select the most representative sample of schools or compare the findings from more than one school.

An additional limitation of this research concerns the unavailability of the teacher owing to time constraints for conducting stimulated-recall interviews or '*reflective dialogue*' sessions. Consequently, it was only possible to conduct informal interviews with Mrs. Celin. Previous research points out the potential benefits of prompting teachers to reflect on their own instructional practices and students' learning processes through showing video recordings of their instructional practices (Dobber *et al.* 2012; Schepens *et al.*, 2007; Whitebread *et al.* 2009). For example, in a recent study carried out by Whitebread *et al.* (2009), asking teachers to watch and reflect on particular video sequences of children's behaviour indicative of metacognition or self-regulation was found to be beneficial for the researchers in understanding the context of the learning task. This additional data contributed to validating the coding framework used to analyse their observational data. In this current thesis research, it would have been helpful to obtain Mrs. Celin's reflections on the video recordings of her own and students' interactions and actions during the scientific inquiry activities, although having her reflect on her own activities in the lessons may have caused changes in her actual behaviour in the subsequent lessons.

Moreover, the opportunity to carry out stimulated-recall interviews with the groups A and B only occurred twice during the data collection process also owing to time constraints. Hence it was not possible to explore students' reflections on all the episodes indicating regulation of learning processes. However, even though the analysis of the stimulated-recall group interviews was able to corroborate only some of the analysis of observational data, it proved to be helpful in providing important

insight into the development of the coding scheme as well as the overall analyses of data set.

7.4 Implications of the study

There are a number of practical implications from the outcomes of this research that science teachers and students may benefit from, particularly if these are also verified by further research. Considering its findings which indicate self and social forms of metacognitive, motivational and emotional regulation processes as crucial for students' successful engagement in the scientific inquiry activities (see Section 7.2), the current study highlights the importance of fostering and facilitating students' acquisition and use of self-, co-, and shared regulation processes. In particular, the findings point to several ways for supporting students' regulation of learning in science classrooms, including carefully designing scientific inquiry tasks, preparing students for the small group collaborative work, and using effective forms of pedagogical interactions and discourse with the students.

Firstly, the results of this study suggest that scientific inquiry group tasks should be carefully designed in a way that promotes students' self and social forms of regulation processes. More specifically, careful attention should be given to the difficulty level of the inquiry tasks. That is, as mentioned in Section 5.4.1, the current study and the previous research (e.g., Iiskala *et al.*, 2011; Perry *et al.*, 2002; Whitebread & Coltman, 2010) have elicited that students engage in metacognitive regulation processes more frequently when the learning task presents an appropriate level of cognitive challenges rather than when undertaking easy or extremely difficult ones. Considering these findings, it appears essential for teachers and curriculum developers to take into consideration the task difficulty level in relation to the particular students and design the scientific inquiry tasks with the appropriate level of complexity in order to increase their potential to enhance their use of self and social forms of regulation processes. Furthermore, as the extant research literature recommends, in order to facilitate students' regulation of learning, the learning tasks should also be designed as open-ended, stimulating individuals' interest and curiosity, encouraging them to seek more than one answer or idea, and provide

opportunities for autonomy, making choices and self-evaluation (Boekaerts & Cascallar, 2006; Hutchinson & Perry, 2012; Perry & Rahim, 2011).

Secondly, in the light of the findings of this study, it appears essential that students should receive training in terms of different aspects of their group interactions. This type of training should include promoting positive and supportive interpersonal interactions among them for as the current study has identified this is highly important for facilitating and sustaining their use of social regulation processes (see Section 7.2.3). Moreover, considering the findings which show the importance of collaborative interactions in the emergence of social forms of regulation processes (see Section 7.2.1), this training should also emphasise the value of collaborative learning and foster effective types of collaborative interactions amongst the students. Some of the approaches cited in the literature could be employed as a potential model for this. For instance, the ‘relational’ approach developed by Kutnick and his colleagues (Baines *et al.*, 2009; Blatchford *et al.*, 2003; Kutnick & Colwell, 2010) which aims to improve students’ social, communication and advanced group working skills could prove fruitful. Also, Webb *et al.*’s (2006) training approach which aimed to develop students’ social and communication skills for small group collaborative activities in mathematics education in the US could be another potential training approach. Providing training which aims to foster effective collaboration among students along with a positive quality of interpersonal interactions can create an optimal social environment for effective group functioning which supports the emergence of social forms of regulation processes, while also at the same time decreasing the possibility of experiencing emotional and motivational challenges within groups. Obviously, the impact of such training programmes on students’ learning would need to be tested and explored in detail in future research studies.

Thirdly, teachers should engage in effective types of pedagogical interactions and discourse that can support students’ self and social forms of regulation processes. In relation to this, the findings in this thesis and some other studies (e.g., Meyer & Turner, 2002; Whitebread & Coltman, 2010; Hutchinson & Perry, 2012) indicate that particular types of interactions between the teacher and students have the potential to facilitate the emergence of such processes. In this study, as explained in section 7.2.3, the teacher regularly encouraged students to share their ideas and questions,

prompted them to justify and reflect on their point of views, and used a non-judgemental tone when responding to them. She also strived to incorporate their ideas and questions into the flow of classroom discussions, thereby showing that she was interested in what they had to say. Moreover, she promoted collaborative dialogue for the group work through emphasising the shared responsibility of the students and the value of collaboration for effective learning. In sum, all these interactions appeared to create a positive social climate in which the students could freely and comfortably articulate their thinking and feelings, and hence easily receive or provide co-regulatory support or engage in shared regulation processes as a group. In the light of these findings, it would appear to be crucial to train science teachers in adopting and using effective types of pedagogical interactions with students during both whole class and small group inquiry activities in order to enhance opportunities for them to self and socially regulate their learning process.

7.5 Future directions for research

Having investigated upper primary students' self and social forms of regulation processes in a naturalistic scientific inquiry learning setting over time, the findings of this study have elicited a number of issues which could be drawn upon for future research.

Firstly, regarding the findings of this study on the interplay between different types of regulation processes (see Section 4.5), it would be fruitful to continue to explore the dynamic and reciprocal nature of regulation processes in different learning settings and subject areas. Extending this line of research would contribute to our understanding of how self and social forms of metacognitive, emotional and motivational regulation are interrelated with each other as well as how they influence students' individual and joint learning in various learning situations. Moreover, information from such studies could be used to understand how to activate, scaffold and support students' regulation of learning processes more effectively.

It would be also beneficial to explore further the influence of individual and group level characteristics on self and social regulation of learning with a wider range of students in terms of age, academic ability, and sociocultural background. As

mentioned in Section 5.4, the student groups observed in this study showed different characteristics (such as in terms of personal and social goals, participation roles within group tasks, ideas about the role of collaboration, perceived emotional and academic peer support, and the nature of friendship) which appeared to explain some of the intergroup and within-group differences in their use of metacognitive, emotional and motivational regulation processes across the sequence of small group inquiry tasks over time. Therefore, understanding how the emergence of self and social regulation processes can be associated with diverse individual and/or group characteristics presents another fruitful area for future research, as it would assist teachers in creating more optimal student groupings which would then promote more effective interactions and inclusive collaboration for the group tasks.

In addition, it would be particularly valuable to explore the effects of a training programme for students which addresses individually or simultaneously both their relational and group work skills or a short course providing them with explicit instructions on self and social forms of metacognitive, emotional and motivational regulation strategies. This type of research, which could be designed and implemented in collaboration with the teachers, can provide deeper understanding of how students' self and social regulation processes could be enhanced and supported in a variety of collaborative learning situations, but also give the practitioners direction in how to implement this.

Also, considering the results of this study which have revealed links between students' use of regulation processes and the nature of talk between them and the teacher (see Section 7.2.3), it would certainly be beneficial to explore how the features of classroom dialogue can assist or inhibit students' self and social forms of metacognitive, emotional and motivational regulation processes during both whole class and small group activities. This line of research may help in characterising the effective types of pedagogical interactions and classroom features that have the potential to support students becoming successful self and socially regulated learners.

Finally, while this study's outcome indicates that students' use of self and social forms of regulation processes is important for their successful engagement with the scientific inquiry activities (see Section 7.2), these findings have not been linked

with students' actual science achievement, since this was not the intention. However, considering the previous research which suggests that there is a significant positive relationship between students' use of regulation processes and their science achievement (e.g., Saab *et al.*, 2011; Winters & Alexander, 2010), there is certainly a need for further research exploring how the types of self and social regulation processes are associated with students' academic performance during scientific inquiry learning.

7.6 Final words

Learning through the scientific inquiry approach is increasingly becoming commonplace in many science classrooms around the world. Students are expected to develop understanding of the nature of science and scientific inquiry, so that they can understand and contribute to socioscientific issues and debates that influence the increasingly scientific and technological societies of the new century. While the importance of scientific inquiry approach in science education is widely acknowledged, there is also still an ongoing debate among scholars, educators and policy makers concerning: how the pedagogical potential of scientific inquiry learning can be harnessed by teachers across multiple activities and contexts, how the processes of scientific inquiry learning can be supported both in and beyond the school setting, and what are the effective forms of interactions that shape students' scientific inquiry learning process. The research in this thesis has sought to contribute to this current discussion by exploring the upper primary students' self-, co-, and shared regulation of learning processes during their engagement in scientific inquiry activities. In general, the findings of this study have elicited that for successful engagement with scientific inquiry learning, it is critical for students to use self and social forms of metacognitive, motivational and emotional regulation, and several ways to support and promote students' regulation of learning processes have been recommended. It is my hope that this research will inform researchers, teachers as well as curriculum developers about the importance of students' regulation of learning processes, and hence contribute to the development of better, more effective practices regarding scientific inquiry learning.

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APPENDICES

Appendix A – An overview of three popular SRL models

A. Socio-cognitive perspective of SRL

According to social cognitive theory (Bandura, 1986), individuals' functioning is influenced by the reciprocal interactions between personal, behavioural, and environmental factors (Schunk, 2001). The application of this theoretical perspective to SRL assumes that individuals' attempts to self-regulate their learning are not determined by only personal processes, such as cognitive or affective, but also these processes are influenced by behavioural and environmental factors that are assumed to be in a reciprocal interaction with each other (Schunk, 2001; Zimmerman, 2000). Socio-cognitive researchers have utilised this perspective in explaining how students develop SRL skills, and how they engage in SRL processes during learning.

In socio-cognitive theory, the development of self-regulatory competence is described in terms of four levels: *observation*, *emulation*, *self-control*, and *self-regulation* (Schunk, 2001; Zimmerman, 2000). At the observational level, novice learners acquire SRL skills and strategies mainly by means of observing models. At this level, students learn the important features of strategies, and require practicing these strategies with instrumental feedback to develop the skills. A second or emulative level is achieved when the learner's behavioural performance resembles the model's behaviour. At this level, the learner acquires capabilities to perform the skills. Schunk (2001) suggests that both observational and emulative level of learning rely on social sources, and learners are not able to perform the skills without models during these levels. The third, self-controlled, level is attained when learners are capable of using the skill or strategy independently while performing the task (Schunk, 2001). At this level, students internalise skills and strategies, but still they 'have not developed an independent representation or begun to internally modify the performance based on what they believe will be most effective' (*ibid*, p.136). At the final SRL level, learners become capable of adapting their skills and strategies systematically according to changing personal and contextual conditions. Consequently, socio-cognitive perspective claims that the development of SRL initially begins with 'social sources and subsequently shifts to self-sources in a series of levels' (Schunk, 2001, p.135).

The role of SRL skills during learning is also described in Zimmerman's (2000) social-cognitive model of SRL. From this perspective, SRL is defined as 'self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal

goals' (Zimmerman, 2000, p.14). Successful learners are assumed to actively engage in cognitive, motivational, and behavioural processes to accomplish self-set learning goals (Cleary & Zimmerman, 2004). This model includes three cyclical phases, namely, *forethought*, *performance control*, and *self-reflection* (Schunk, 2001; Zimmerman, 2000).

According to this model, the processes that occur during the *forethought* phase set the stage for learning (Cleary & Zimmerman, 2004). These processes include task analysis and self-motivational beliefs. Task analysis includes goal setting and strategic planning processes. As a key aspect of task analysis, goal setting is described as decision making on specific outcomes of learning or performance (*ibid*). Strategic planning refers to selecting or creating strategies that helps learners enhance their performance during the learning process (Zimmerman, 2000). Self-motivational beliefs, such as self-efficacy, intrinsic motivation, and outcome expectation, are assumed to play an important role in influencing learners' use of SRL processes (*ibid*).

These *forethought* processes influence how students engage in the *performance control* phase processes. In this phase, 'students actively engage in a specific learning activity and employ self-control and self-observation processes to maximize their learning' (Cleary & Zimmerman, 2004, p.539). Self-control processes allow learners to focus on the learning task or performance, and include sub-processes, such as imagery, task strategies, self-instruction, or attention focusing. Self-observation refers to systematic monitoring of one's own performance in the light of the standards and goals. During this phase, highly self-regulated learners are assumed to implement their strategic plan, and engage in various self-monitoring processes to obtain information that will be used for the evaluation of strategic plan and the improvement of subsequent learning efforts (*ibid*).

Finally, *self-reflection* phase refers to the evaluation of one's own performance based on the information created through self-observation processes, and includes two general processes: self-judgement, and self-reaction. Self-judgment processes compare 'existing performance levels, as observed, with one's learning goals' (Zimmerman, 2001, p.21). Through self-reaction processes, learners draw adaptive inferences 'about whether to modify their learning strategies or methods of learning during future learning or performance attempts' (Cleary & Zimmerman, 2004, p. 539). Since these phases are cyclical, feedback obtained from self-reflection processes influence *forethought* phase for the subsequent learning attempts (Zimmerman, 2000). Furthermore, environmental factors influence learners' SRL processes. For instance, self-observation, self-judgment, and self-reaction are considered as important processes of SRL that are interdependent to each other. However, 'these sub-processes also

do not operate independently of the learning environment' (Schunk, 2001, p. 130). For instance, after engaging in self-judgment and self-reaction processes, learners may consider their progress as inadequate, and they may ask for help from their peers or teacher in their learning environment.

In the socio-cognitive perspective of SRL, the relationship between self and social is considered as one of related, but distinct, entities (Meyer & Turner, 2002). Social context is viewed as an important component influencing and enhancing individuals' SRL processes. It provides opportunities for modelling, social guidance, and instrumental feedback, which each play an important role to assist individuals in their self-regulation of cognition, motivation, and behaviour (Hadwin *et al.*, 2010; Zimmerman, 2000). Furthermore, by means of these social processes, the individual develops SRL competence in relation to the task, content, and context, thus becomes a self-regulated learner. Consequently, socio-cognitive perspective views SRL as 'a developing process within the individual' (Hadwin *et al.*, 2010, p.3), while social aspects of SRL are conceptualised as contextual elements influencing individual learners' SRL processes (Järvenoja & Järvelä, 2009).

B. Pintrich's conceptual framework of SRL

Mainly based on a social cognitive perspective, Pintrich (2000, 2004) proposed a conceptual framework of SRL that is comprised of forethought, monitoring, control, and reaction and reflection phases that learners follow while performing the learning task. For each of these four phases, Pintrich identifies four possible areas in which self-regulation can occur, namely, cognition, motivation and affect, behaviour, and context.

According to this framework, in the forethought phase, students set specific goals for their learning, and activate relevant prior content knowledge and metacognitive knowledge that they have about cognitive tasks and strategies or themselves (cognitive area). Students also activate various types of motivational beliefs, such as goal orientation, self-efficacy beliefs, and personal interest (motivational area). They plan time and effort for the learning task (behavioural area), and activate their perceptions and knowledge of the task and the context (context area).

The second phase, monitoring, involves metacognitive awareness and monitoring of various facets of cognition (cognitive area). In this phase, students are also assumed to be aware of their motivational beliefs and affects, and 'monitor them at some level' (motivational area) (Pintrich, 2000, p.463). They can monitor their time use, effort, and need for help

(behavioural area), as well as the task and the contextual aspects of the classroom during the learning process (context area). Through these monitoring processes, students compare their current progress with goals to create information for the subsequent phase.

In the control phase, students engage in various cognitive and metacognitive activities for adapting or changing their cognition (cognitive area), use various strategies for controlling and regulating their motivation and affect (motivational area), control and regulate their effort, or engage in help seeking strategies (behavioural area), and attempt to control the task or the context (context area).

Finally, in the last phase, students engage in reactions and reflection processes to make judgments, attributions, and evaluations of their performance. According to Pintrich (2004), while these phases present a time-ordered sequence that learners go through when performing a task, it does not imply that the phases are hierarchically or linearly structured. They may occur at any time during the learning process. Also, some of the phases may occur simultaneously, as learners can engage in monitoring, control, and reaction phases concurrently.

C. Winne's Four-Stage Model of SRL

Winne and Hadwin (1998) propose a model of SRL that is based on both the perspectives of information processing theory and social cognitive theory. Their model characterises SRL as an event that consists of four phases, namely, task definition, goal setting and planning, enactment, and adaptations to metacognition (Winne, 2001). Each phase of this model is assumed to share the same general cognitive architecture, described as COPES typology: conditions, operations, products, evaluations, and standards.

Conditions refer to the resources available to a learner and the constraints that may influence information processing (Winne, 2001). Two types of conditions are identified in the model. Cognitive conditions refer to the information activated and retrieved from long-term memory (e.g., motivational factors, prior domain knowledge, knowledge of study tactics and strategies). Task conditions refer to the contextual constraints and affordances, such as resources, instructional cues, time, and social context (Perry & Winne, 2006). Conditions are assumed to have an influence on the whole learning process, in particular on the operations and standards. Standards refer to the criteria that learners set against which products are monitored (Winne & Hadwin, 1998). Operations are described as the information processes - searching, monitoring, assembling, rehearsing, and translating (SMART) - that occur during

learning (Winne, 2001). Products are new information created in each phase when existing information is manipulated by the information processes (*i.e.*, SMART) (*ibid*). Evaluations consist of internally generated or externally provided feedback about the products created in each phase. It occurs during the whole learning process, while learners metacognitively monitor and control their learning processes.

Overall, Winne and Hadwin's (1998) model consists of four weakly sequenced and recursive phases. In the first phase, learners generate a perception about the learning task in the light of both task conditions and cognitive conditions. In the second phase, learners set goals and plans in relation to their understanding of the task. Then, they engage in selecting study tactics and learning strategies that they envisage can help attaining the learning goals (Perry & Winne, 2006). In the enactment phase, learners engage in learning processes by applying tactics and strategies selected for the task, and create products for each cognitive operation. In the final phase, depending on the evaluations of products, either internally generated or externally provided, learners may decide to make important adaptations for self-regulatory processes taking place in previous phases (*ibid*). They may alter their understanding of the task, or adjust learning goals or strategies.

Winne and Hadwin's (1998) model of SRL clearly concentrates more on the cognitive architecture of self-regulation. It illustrates how learners may adapt their SRL processes in the light of a specific cognitive system or architecture. This model specifies how task conditions and cognitive conditions may directly influence the standards that learners set and the cognitive processes, tactics, and strategies that students engage while performing the learning task (Winne & Hadwin, 1998). Furthermore, metacognitive monitoring and control are considered as central elements of this model that produce internal feedback in order to inform learners about the inconsistencies between products and standards for each phase (Winne, 2001).

Winne and Hadwin's (1998) model of SRL subsumes social context in task conditions (Greene & Azevedo, 2007b). According to this standpoint, when social context is transformed into specific information through information processes, it can influence the whole learning process like other sources of information (Zimmerman, 2001). In Winne and Hadwin's model, thus, SRL is perceived as an individual process that relies on the individual's information processing capabilities (McCaslin *et al.*, 2006). Consequently, the attention is given largely to the individual who perceives social and environmental cues, and engages in various SRL processes, rather than motivational and social aspects of SRL.

Appendix B – Sequence and duration of small group and whole class inquiry activities

Lessons	Activities	Focus of the activity	Duration of the observations analysed
Lesson 2	Introductory activity 1	Digestive system	30 Min
Lesson 3	Small group activity 1	‘Why do we eat?’ small group activity	2x35 Min
Lesson 3 – 5	Whole class discussion 1	Digestive system	60 Min
Lesson 5 – 6	Small group activity 2	‘Journey of food’ small group activity	2x45 Min
Lesson 6	Whole class discussion 2	Digestive system	20 Min
Lesson 7	Introductory activity 2	Nervous system	20 Min
Lesson 7	Small group activity 3	‘Football match’ small group activity	2x22 Min
Lesson 8 – 9	Whole class discussion 3	Nervous system	60 Min
Lesson 9 – 10	Small group activity 4	‘Poisonous plant’ small group activity	2x28 Min
Lesson 10	Whole class discussion 4	Nervous system	30 Min
Lesson 11 – 12	Introductory activity 3	Excretory System	60 Min
Lesson 13 – 15	These three lessons could not be observed due to the absence of Mrs. Celin		
Lesson 16	Small group activity 5	‘Water content of our body’ small group activity	2x33 Min
Lesson 17	Whole class discussion 5	Excretory System	27 Min

Appendix C - Sample lesson plans and group activity worksheets

A) Sample lesson plans from the Curriculum Guide Book (MoNE, 2008)

Sindirim Sistemi ve Sindirim Sisteminin Bağlı Vücudumuzda Sistemler

Sindirim Yardımcı Organlar

Aşağıdaki göklerden yararlanarak karaciğer ve pankreasın sindirim sistemindeki görevlerinin neler olduğunu belirleyelim.

Karaciğer
Safra adı verilen bir salgı üretir. Safra suyu büyük yağ damlacıklarını daha küçük parçalarla ayırarak yağların sindirimine yardımcı olur.

Pankreas
Pankreas öz suyunu salgılar. Pankreas öz suyu, proteinlerin, karbohidratların ve yağların sindirimi için gerekli olan enzimler içerir.

6. Sınıf
76. s.

Karaciğer ve pankreas sindirime yardımcı organlardır. Bu organlar ürettikleri safra salgısı ve pankreas öz suyunu besin içeriklerinin sindirimi için tamamlamak üzere bir kanalla ince bağırsığa atarlar.

Sindirime Enzimlerin Besin İçeriklerine Etkisi

Aşağıdaki genayla inceleyerek enzimlerin kimyasal sindirimdeki işlevini açıklayabilir misiniz?

17. Sınıf

Besin içeriklerinin her birinin sindirim sırasında küçük moleküllere parçalanmadığı vurgulanmalıdır. Ayrıca besin içeriklerinden karbonhidrat, yağ ve proteinlerin sindirime uğradığı ve ince bağırsaktan emilerek kana geçtiği belirtilir. Sindirim sisteminde besin içeriklerinin geçirdiği değişimi gösteren şema öğrencilere incelenir ve şemaya ait soruları cevaplamaları sağlanır. Besin içeriklerinin vücudumuzda sindirildiği yer ve sindirim sonucu oluşan küçük moleküller, sindirim sonucu oluşan ürünlerin kana geçişi ve bunların kan yolu ile hücrelere taşınması şemada açıklanmıştır. Su, vitamin ve minerallerin sindirime uğramadan kalın bağırsaktan emildikleri ve kana karışıklarına öğrencilerin dikkati çekilmelidir.

7. Etkinlik: Görevim Nedir?

Bu etkinliğin amacı, öğrencilerin sindirim sistemi yapı ve organlarına ait olan resimlerin altındaki boşluklara bu yapı ve organların sindirimdeki görevlerini yazmalarını sağlamaktır.

Öğrencilere "Sindirim sistemimizde besinlerin ne kadar sürede sindirildiğini biliyor musunuz?" sorusu sorulur. Sindirim sisteminin her bir organında besinlerin kalma süresini belirten aşağıdaki çizelge ile ilgili "Bir besini ağızımızda kaç saniye çiğneriz?", "Yediğimiz elma midemizde kaç saat kalır?" gibi sorular sorulup tahminleri alınarak konuyu öğrencilerin vücutlarında gerçekleşen sindirim olayıyla ilişkilendirmeleri sağlanır.

Sindirim Sistemi Organları	Süre (Yaklaşık değerler)
Ağız	20 s
Yemek borusu	10 s
Mide	2-6 h
İnce bağırsak	5 h
Kalın bağırsak	24 h

7. Etkinlik: Görevim Nedir?

Aşağıda sindirimde görevli organ ve yapılar görülmektedir. Bu yapı ve organların sindirimdeki görevlerini ilgili yerlere yazalım.

Yutak: Besinleri ağızdan yemek borusuna iletir.

Yemek Borusu: Çiğneme sonrasında besinleri mideye iletir.

Karaciğer: Ürettiği safra salgısını yağların fiziksel sindirimini gerçekleştirmek üzere ince bağırsığa gönderir.

Pankreas: Proteinlerin, karbohidratların ve yağların sindirimini gerçekleştiren pankreas öz suyunu salgılar.

Anüs: Besinlerin vücudumuz tarafından kullanılmayan bölümünü dışık olarak vücuttan uzaklaştırır.

Ağız: Besinlerin fiziksel sindirimi ve karbohidratların kimyasal sindirimini ağızda başlar.

Mide: Kalıplı gevreyerek besinleri fiziksel sindirimle küçük parçalara ayırır ve kimyasal sindirimi ile küçük moleküllere bölüne getirir.

İnce Bağırsak: Besinlerin en küçük parçalara kadar ayrıldığı ve emilimin gerçekleştiği organdır.

Kalın Bağırsak: Besinlerin içerisinde kalan su ve mineraller emilir. Atık maddeler anüse gönderilir.

17. Sınıf

Öğrencilere Ders Kitabı'nın 20. sayfasında yer alan enzimlerin besin içeriklerine etkisini açıklayan şema incelenir ve şemayla ilgili sorular cevaplandırılır. Ardından öğrencilere "Sindirilen Besin İçeriklerine Ne Olur?" başlığı altında yer alan şema da incelenir ve öğrencilerden şemadan faydalanarak hangi besin içeriklerinin ince bağırsaktan hangi besin içeriklerinin ise kalın bağırsaktan kana geçtiğini bulmaları istenir. Yağların ince bağırsakta sindirildikten lenf damarına verildiği daha sonra lenf damarından kan dolaşımına katılarak hücrelere taşındığına öğrencilerin dikkati çekilmelidir.

Genişletme Aşaması

Öğrencilere Çalışma Kitabı'ndaki "Yiyecekleri Neden Sindiriyoruz?" adlı 8. Etkinlik ev ödevi olarak verilir.

8. Etkinlik: Yiyecekleri Neden Sindiriyoruz?

Bu etkinliğin amacı, öğrencilerin sayfanın üst kısmında verilen şemayı inceleyerek enzimlerin kimyasal sindirimdeki işlevi ile besinlerin fiziksel ve kimyasal sindirime uğramasının sebebini açıklamalarını ve sayfanın altında verilen resimden faydalanarak besin içeriklerinin yolculuğunu sembollerle göstermelerini sağlamaktır. Bir sonraki derste öğrencilerin verdikleri cevaplar kontrol edilerek eksikliklerin giderilmesi sağlanır.

Öğrencilere "Besinlerin Uzun Yolculuğu" adlı 1. Alternatif Etkinlik yaptırılabilir.

1. Alternatif Etkinlik: Besinlerin Uzun Yolculuğu

Bu etkinlikte amaç, öğrencilerin sindirim sistemini oluşturan organlar sindirim sistemine yardımcı organlar, bu organlarda salgılanan ya da bulunan sıvı, sindirim çeşidi, sindirilen besin içeriği ve emilim olayı ile ilgili bilgilerini pekiştirmelerini sağlamaktır.

Öğrencilere, "Peki, hücrelerimize kadar taşınan bu besin içeriklerinin vücudumuzda hangi olaylar için kullanıldığını biliyor musunuz?" sorusu sorulur. Öğrencilere, Ders Kitabı'nın 21. sayfasında yer alan karikatürleri inceleyerek bu soruyu cevaplayabilecekleri söylenir. Ardından vücudumuzun bu molekülleri, enerji üretmek, büyümek, onarım ve hastalıklarla savaş için kullandığı vurgulanmalıdır. Öğrencilere proteinlerin vücudumuzda öncelikle yapım ve onarım için kullanıldığı, gerektiğinde enerji elde etmek için de kullanılabileceği belirtilmelidir.

Ardından öğrencilere "Araştırılım, Hazırlanalım" bölümündeki çalışma yaptırılır.

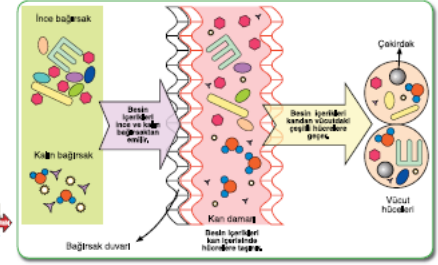
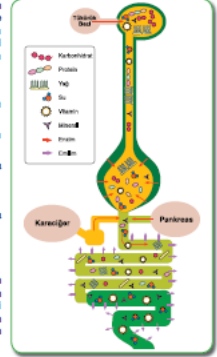
Enzimler, büyük moleküllü besin içeriklerini küçük moleküllü besinlere dönüştürmekle görevlidir. Vardaki şemada sindirim sistemimizde besin içeriklerinin kimyasal sindirim sırasında geçirdikleri değişim görülmektedir.

Şemayı inceleyerek aşağıdaki soruları cevaplayalım.

1. Besin içeriklerinin her biri, sindirim sırasında nasıl bir değişime uğrar?
2. Besin içerikleri hangi organlardan kana geçer?
3. Kana geçen besin içeriklerine ne olur?
4. Sindirilmeyen besinler niçin kana geçmez?

Sindirilen Besin İçeriklerine Ne Olur?

Aşağıdaki şemada sindirime uğrayan besinlerin emilim ile bağırsaklardan kana, kandan vücut hücrelerine geçtiği görülmektedir. Besin içeriklerinin hangilerinin ince bağırsak, hangilerinin kalın bağırsaktan kana geçtiğini söyleyebilir misiniz?



1. Alternatif Etkinlik: Besinlerin Uzun Yolculuğu

Sindirim sistemimiz ile ilgili aşağıda verilen çizelgeyi inceleyelim. Çizelgedeki sütun başlıklarını dikkate alarak boşlukları verilen örneğe uygun olarak dolduralım.

	Organlar	Salgılanan/ Bulunan Sıvı	Fiziksel Sindirim	Kimyasal Sindirim	Sindirilen Besin İçeriği
Sindirim Sistemi Organları					
	ince bağırsak	safra salgısı pankreas özsuyu	-	+	protein yağ karbonhidrat
Yardımcı Organlar					

Merkezî sinir sistemi dışında yer alan milyonlarca sinirin çevresel sinir sistemini oluşturduğu vurgulanır. Çevresel sinir sisteminin, merkezî sinir sistemi ile organlar arasındaki iletişimi sağladığı belirtilir.

Öğrencilere “Basit bir elektrik devresinde elektrik enerjisinin taşınmasını sağlayan nedir?” sorusu sorularak, onların 6. sınıf “Yaşamımızdaki Elektrik” ünitesinde öğrendikleri elektrik enerjisinin iletimi ile ilgili ön bilgilerinden yararlanarak sinirlerdeki iletimin elektrik kablolarındaki elektrik enerjisinin iletimi ile benzer olduğunu anlamaları sağlanır.

Öğrencilere Çalışma Kitabı’ndaki “Denetleyici ve Düzenleyici Sistemimiz” adlı 17. Etkinlik yaptırılır.

17. Etkinlik Denetleyici ve Düzenleyici Sistemimiz

Bu etkinliğin amacı, öğrencilerin sinir sistemini oluşturan merkezî sinir sistemi ile çevresel sinir sistemini ayırt etmelerini çevresel sinir sistemini oluşturan organ ve yapıların görevlerini açıklamalarını sağlamaktır.

Genişletme Aşaması

“Sinirlerde mesaj iletimi nasıl gerçekleşir?” sorusu öğrencilere sorularak tahminleri alınır. Sinirlerin bu mesajları nasıl taşıdığını anlayabilmeleri için öğrencilerin uyarı, uyarı mesajı, cevap, tepki kavramlarını öğrenmeleri gerekir. Öğrencilerin bu kavramları sayfada yer alan resimleri inceleyerek ve “Mesajımız Var” oyununu oynayarak öğrenmeleri sağlanır.

Sayfada yer alan “Bunları Biliyor muydunuz?” bölümündeki resimler incelenir. Bu bölüm öğrencilere okutulur ve sinirlerle elektrik kabloları arasındaki benzerliğe dikkat çekilir.

5. Etkinlik: Mesajımız Var

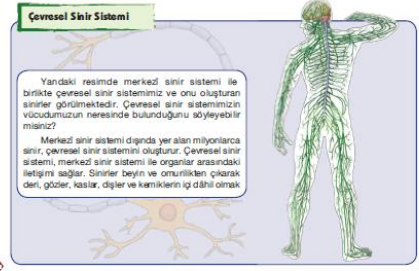
(Önerilen süre: 20 dk.)

Bu etkinliğin amacı, öğrencilerin sinirlerdeki mesaj iletiminin nasıl gerçekleştiğini bir oyunla kavramalarını sağlamaktır. Bunun için öğrencilerin şemada belirtilen görevleri yerine getirecek olan A, B, C, D, E harfli organ ve yapıların isimlerini belirlemeleri sağlanır. Beklenen cevaplar yandaki sayfada yer alan çizelgedeki gibidir.

Gruplardaki öğrenciler etkinlikte yer alan şemadan yararlanarak belirledikleri organların isimlerini kartlara yazar ve bu kartları yakalarına takarak daire oluşturacak şekilde yerleşirler.

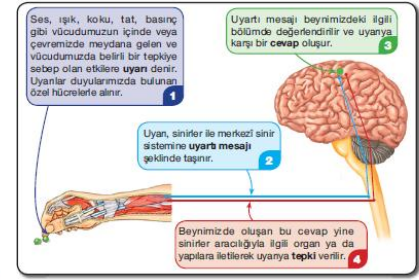
Oyun bir kâğıda yazacağımız basit mesajla (burnunu kaşı, yitir, saçını tara, çiçek kokusu vb.) başlar. Öğrencilerden mesajla ilgili görevlerini yerine getirmeleri istenir. Birinci öğrencinin eline mesaj yazılı kâğıt verilir. “Sinir”i temsil eden öğrenciler, mesajı elden ele taşırlar (sinirsel iletimin simülasyonu). Mesaj “beyin”i temsil eden öğrencide durur. “Beyin” görevini yerine getiren bu öğrenci gelen mesajı alarak yorumlar ve bu mesajla bir cevap yazar. Bu cevap mesajını sinir görevini yerine getiren öğrenciler elden ele taşırlar ve “kas veya organ” temsil eden arkadaşlarına iletir. “Kas veya organ”ı temsil eden öğrenci beyinden gelen mesajı okur ve uygular.

Örneğin, öğretmen uyarı mesajı olan “burnunu kaşınması” mesajını “sinir”i temsil eden öğrenciye verir. “sinir” görevindeki öğrenciler uyarı



17. Etkinlik

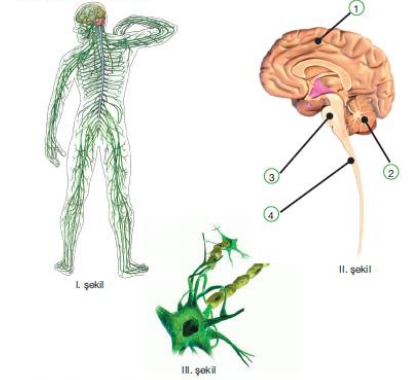
Peki, bu iletişim nasıl gerçekleşir? Sinirlerin bilgi taşıma özelliği sayesinde, çevremizde ve vücudumuzda meydana gelen değişimler hakkında hızlı bir şekilde bilgi ediniriz. Sinirleri, telefon kablolarına benzetebiliriz. Telefon kabloları gibi sinirler de bilgi taşıyarak vücudumuzdaki iletişimi sağlar. Bu iletişimin nasıl gerçekleştiğini anlamak için aşağıdaki şemayı inceleyelim.



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17. Etkinlik : Denetleyici ve Düzenleyici Sistemimiz

Aşağıda verilen resimleri inceleyerek her bir maddede bizden istenilenleri maddelerin altındaki boşluklara yazalım.



- I. şekilde sinir sisteminin hangi bölümleri görülmektedir?
Merkezî ve çevresel sinir sistemi.
- II. şekilde numaralarla gösterilmiş yapı ve organların adlarını ve görevlerini yazalım.
1. Beyin: Vücudumuzun yönetimi, hareket ve düşünme merkezidir.
2. Beyincik: Vücudumuzun dengesi ve denge merkezidir.
3. Omurilik: Solunum, iç organlarımızın çalışmasını kontrol eder.
4. Omurilik: Refleks yönetim merkezidir ve beyine diğer organlar arasındaki bilgi iletişimi sağlar.
- III. şekilde görülen organ ve yapılar hangi sistemde yer alır?
Merkezî sinir sistemi.
- III. şekilde görülen yapının ismi ve görevi nedir?
Sinir hücreciği. Vücudumuzdan ve çevreden aldığı bilgileri beyimize iletir.

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Boşaltım Sistemimiz Vücudumuzdan Atıkları Uzaklaştırır

• Konuya Başlarken

KAZANIMLAR	2. Boşaltım sistemi ile ilgili olarak öğrenciler; 2.1. Boşaltım sistemini oluşturan yapı ve organları; model, levha ve/veya şema üzerinde gösterir (FTTÇ-4). 2.2. Boşaltım sisteminde böbreklerin görevini ve önemini açıklar. 2.3. Boşaltım sistemi sağlığının korunması için alınabilecek önlemlerin farkına varır. 2.4. Bazı böbrek rahatsızlıklarının tedavisinde kullanılan teknolojik gelişmelere örnekler verir (FTTÇ-5, 17, 29, 30, 32).
AÇIKLAMALAR	Sınırlamalar • 2.2. Nefronun boşaltımdaki önemi vurgulanır, yapısı anlatılmadan şekil olarak verilir. [!] Uyarılar • 2.2. Boşaltımda deri, akciğer ve karaciğerin görevleri de vurgulanır. • 2.4. Böbrek yetmezliği, böbrek nakli, diyaliz, böbrek taşı, yüksek frekanslı ses dalgaları ve lazer gibi teşhis/televi yöntemleri vurgulanır. [] Diğer Derslerle İlişkilendirme • 2.4. kazanımı, Sosyal Bilgiler dersi 6. sınıf "Bilim, Teknoloji ve Toplum" öğrenme alanı, "Elektronik Yüzyıl" ünitesi kazanım 3 (Tıp alanındaki buluş ve gelişmelerle insan hayatı ve toplumsal dayanışma arasındaki ilişkiyi fark eder.) ile ilişkilendirilir. [] Ders İçi İlişkilendirme • 2.1-2.2. 5. sınıf "Vücudumuz Bilmecesini Çözelim" ünitesi "Zararlı Maddelerin Boşaltımı" konusu ile ilişkilendirilir.

• Öğrenciler Neredeler, Nereye Gelecekler?

Öğrenciler boşaltımda görevli organ ve yapıların yeri, boşaltım organlarının görevinin vücutta çeşitli faaliyetleri sonucunda oluşan zararlı maddelerin vücuttan dışarı atılması olduğu, boşaltımda atık maddelerin dışarı atılmasını sağlayan yapı ve organları, böbreklerin sağlığı için nelere dikkat edilmesi gerektiği ön bilgilerine sahiptirler.

Bu konuda öğrencilerden boşaltım sistemini oluşturan yapı ve organları model üzerinde göstermeleri, böbreklerin boşaltım sistemindeki görevini ve önemini açıklamaları, boşaltım sistemi sağlığını korumak için alınabilecek önlemlerin farkına varmaları ve bazı böbrek rahatsızlıklarının tedavisinde kullanılan teknolojik gelişmelere örnekler vermeleri beklenmektedir.

Ön Bilgileri Yoklama ve Morak Uyandırma Aşaması

• Anahtar Kavramlar

Öğrencilere nefron ve diyaliz anahtar kavramlarıyla ilgili neler bildikleri sorulur. Öğrencilerden, anahtar kavramlar hakkındaki düşüncelerini sözlü olarak ifade etmeleri beklenir. Öğrencilere konu sonunda bu kavramlara tekrar dönmeleri hatırlatılır.

• Konuya Giriş

Öğrencilerin dikkatlerini konuya çekmek amacıyla Ders Kitabı'nın 24. sayfasında yer alan fotoğraf incelenir. Böbrek yetmezliği ile ilgili paragraf okutulur ve metnin altında yer alan soruların cevapları sınıfta tartışılır.

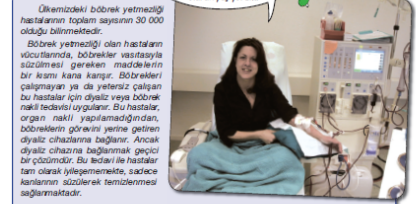


Boşaltım Sistemimiz Vücudumuzdan Atıkları Uzaklaştırır

Anahtar Kavramlar

nefron
diyaliz

Ben bir böbrek hastasıyım. Haftada en az üç gün dört saat boyunca, yani ortalama 48 saat diyaliz cihazına bağlı olarak yaşıyorum.



Ülkemizdeki böbrek yetmezliği hastalarının toplam sayısının 30 000 olduğu bilinmektedir. Böbrek yetmezliği olan hastaların vücutlarında, böbrekler vasıtasıyla süzülmesi gereken maddelerin bir kısmı kana karışır. Böbrekleri çalışmayan ya da yetersiz çalışan bu hastalar için diyaliz veya böbrek nakli tedavisi uygulanır. Bu hastalar, organ nakli yapılmadığından, böbreklerin görevini yerine getiren diyaliz cihazına bağlanırlar. Ancak diyaliz cihazına bağlanmak geçici bir çözümdür. Bu tedavi ile hastalar tam olarak iyileşmezler, sadece kanlarının süzülerek temizlenmesi sağlanmaktadır.

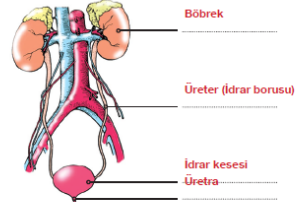
Böbrek yetmezliği hastalarının tam olarak tedavi edilebilmesi için böbrek nakli yapılması gerekmektedir. Böbrek nakli olabilmek umuduyla hayatlarını sürdürmeye çalışan bu hastalardan yılda yaklaşık 6000'ü bu imkânı kavuşuyor.

Aşağıdaki soruları, yukarıdaki metni dikkate alarak tartışalım:

- Çevremizde böbrek yetmezliği hastası var mı? Böbrek yetmezliği bu hastaların günlük hayatlarını nasıl etkiliyor?
- Diyaliz cihazı, böbrek yetmezliği tedavisinde hangi amaçla kullanılıyor olabilir?
- Böbreklerin vücutumuzdaki görevi ve önemi hakkında ne söyleyebiliriz?
- Böbrek nakli, böbrek yetmezliği hastalarının hayatları açısından nasıl bir öneme sahiptir?
- Böbrek yetmezliği hastaları için, teknolojik gelişmelere de bağlı olarak başka hangi tedavi yöntemleri geliştirilebilir?

M. Etiklik : Boşaltımda Görevli Yapı ve Organlar

A. Boşaltımda görevli yapı ve organları gösteren aşağıdaki şekli inceleyelim. Boşaltımda görevli yapı ve organların isimlerini yanlarındaki ilgili alana yazalım.



Aşağıdaki tamamlanmamış cümleler boşaltımda görevli yapı ve organların görevleriyle ilgilidir. Bu cümlelerdeki boşluklara hangi yapı veya organ isminin gelmesi gerektiğini seçeneeklerden bulalım. Bulduğumuz yapı veya organların isimlerini yukarıda yer alan şeklin uygun yerlerine yazalım.

1. Kanı süzerek zararlı maddelerden, ... arındırır.
A) Akciğer B) Pankreas C) İnce bağırsak **Böbrek**
2. İdrarı, böbrekten idrar kesesine taşır.
A) Böbrek atardamarı B) Böbrek toplardamarı
C) Üreter D) Sperm kanalı
3. İdrar, ... toplar.
A) İdrar kesesinde B) Böbrek toplardamında
C) Böbrekte D) Üreterde
4. İdrarı vücuttan dışarı, ... atar.
A) İdrar kesesi B) Üreter
C) Üretra D) Kalın bağırsak

B. Böbreklerin sağlığını korumak için neler yaparsınız? Listeleyelim.

1. Kişisel temizliğe dikkat etmek.....
2. Günde iki litre su içmek.....
3. Böbrekleri ve idrar yollarını soğuktan korumak.....
4. Yb. cevaplar kabul edilir.....

B) Nervous System Lesson Plan prepared by Mrs. Celin

2. DENETLEYİCİ VE DÜZENLEYİCİ SİSTEMLER

PROBLEM DURUMU ve BAĞ KURMA:

1- Aşağıdaki anahtar kavramlar verilerek ön bilgileri yoklanır. Bu etkinliğin amacı, öğrencilerin dikkatlerini konuya çekmek ve vücudumuzdaki olayların nasıl gerçekleştiğini düşündükleriyle ilgili ön bilgilerini açığa çıkarmaktır.

* Sinir hücresi

* Salgı bezi

* Hormon

1. Yukarıdaki anahtar kavramların ne anlama geldiğini biliyor musunuz?

2. Bu kavramlar hakkındaki düşünceleriniz nelerdir?

KEŞFETME:

2- Sınıf gruplara ayrılır. Öğrencilere futbol oynayan iki takımı gösteren video izlettirilir. İzlettirilmeden önce şu yönergeler verilir ve problem durumu soru kağıdı dağıtılır.:

- Futbolcuların vücutlarında veya çevrelerinde kaç olay gerçekleştiğini belirlemeye çalışınız. Belirlediğiniz olayları defterinize yazınız.
- Grup içinde listenizi tartışarak belirlenen tüm olayları tek bir liste haline getiriniz.
- Bu listeden yararlanarak aşağıdaki soruları grup olarak yanıtlayınız.

Sorular:

1. Futbol oynayan bir kişinin vücudunda ve çevresinde kaç olay meydana gelmektedir?
2. Bu kişinin vücudunda ve çevresinde, futbol oynarken gerçekleşebilecek olay sayısı sadece belirlediğimiz kadar mıdır? Tartışalım.
3. Bu olayların her biri vücudumuzdaki hangi sistem veya sistemler tarafından gerçekleştirilir?
4. Bu olayları gerçekleştiren sistemler birbirlerinden bağımsız olarak mı çalışır?
5. Vücudumuzda bu kadar çok sayıda olay, birbirini engellemeden nasıl gerçekleşebiliyor?

AÇIKLAMA:

3- Aşağıdaki eşitlik tahtaya yazılır ve bu eşitliğe göre öğrencilerin bu sistemle ilgili ne söyleyebilecekleri öğrenilir.

Denetleyici ve Düzenleyici Sistem = Sinir Sistemi + İç Salgı Bezleri (Endokrin sistem)

4-Ödev olarak öğrencilere sinir ve hormonal sistem ile ilgili hazırlanan araştırma kağıdı bir ders öncesinde verilir. Öğrencilerden araştırma kâğıdında yer alan soruları ders kitabından (33, 34, 35, 38, 39 ve 40. sayfalar) ve diğer bilgi kaynaklarından yararlanarak evde cevaplamaları istenir.

5-*Derste öğrenciler gruplara ayrılır ve gruptaki tüm üyelerin sorulara verdikleri cevapları tek tek açıklamaları ve cevaplarını diğer grup üyeleri ile karşılaştırmaları istenir. Bu sayede bütün öğrencilerin hem kendilerini hem de diğer grup üyelerini değerlendirmelerine fırsat tanınmış olunur.*

6- *Gruplar doğru cevapları aralarında tartıştıktan sonra sorular sınıfta ppt. Yardımıyla cevaplanır.*

7- Daha sonra etkinlik sırasında öğrencilerin sinir ve hormonal sisteminin bölümlerini model, levha ve şema üzerinde göstermelerini sağlamak amacıyla sinir ve hormonal sisteminin yapı ve organlarını gösteren model, levha ve/veya şema sınıfa getirilir.

Öğrencilerin bunları incelemeleri sağlanır. (Not: Model ve levha kullanımı ppt ile soruların cevaplanması sırasında da olabilir.)

GENİŞLETME:

8- Bu etkinliğin amacı, öğrencilerin araştırma kısmında öğrenmiş oldukları bilgileri uygulayarak sinirlerde mesaj iletiminin nasıl olduğunu grup çalışması ile araştırıp anlamalarını sağlamaktır. Ayrıca öğrencilerin önceki etkinliklerde öğrenmiş oldukları bilgileri gerçek yaşam koşullarına uygulayıp ilişkilendirmeleri amaçlanmaktadır.

Bu aktivitede dikkat edilmesi gereken noktalar.(öğretmene)

- ✓ Öğrencilerden futbol oynarken kalecinin topu ve diğer oyuncuları izlemesinin, diğer arkadaşlarının konuşmalarına karşılık vermesinin beyin tarafından koordinasyonlu bir şekilde kendi kontrolünde gerçekleştiğinin açıklamaları beklenir. Isırgan otu ile temas ettiği sırada gerçekleşen elini hızlı bir şekilde

çekmesi olayının (refleks) kontrolü dışında omurilik tarafından gerçekleştiği, ama acıyı hissetmesinin ve çığlık atmasının yine beyin tarafından bilinçli olarak oluştuğunu anlamaları beklenir.

- ✓ Öğrencilerin özel duyu hücreleri sayesinde dışarıdan uyarının alındığını ve bu uyarının uyarı mesajı (elektrik sinyali olarak) olarak sinirler tarafından sinir sistemine taşındığı, bu uyarı mesajının beynimizin ya da omuriliğin ilgili yerlerinde değerlendirilip uyarıya karşı bir cevap oluşturulduğu, bu cevabın yine sinirler tarafından ilgili organ ya da yapılara taşınıp uyarıya tepki verildiğini açıklamaları beklenir.

Bunları Yapalım

- Öğrencilere futbol oynayan çocukları gösteren video izletilir soru kağıdı dağıtılır ve şu yönerge verilir:
 - Kaleci olarak görev yapan kişinin sinir sisteminin gerçekleştirdiği olayları gözleyin ve gözlemlerinizi defterlerinize not alın.(bireysel)
 - Grup olarak aldığınız notları karşılaştırarak yeni bir liste oluşturun
 - Oluşturduğunuz listeden yararlanarak aşağıdaki soruları grup olarak cevaplayın.

Sorular:

1. Mac sırasında kalecilik yapan çocuğun sinir sisteminin cevap oluşturduğu olaylar hangileridir? Bu olayların her biri hangi sistem ya da sistemler tarafından gerçekleştirilir?
2. Bu olaylardan hangilerini kaleci çocuk bilinçli olarak kontrol edip, hangileri otomatik olarak gerçekleşmiştir? Grubumuz içinde tartışalım.
3. Gözlemlediğiniz olaylar sırasında sinirlerde mesaj iletiminin nasıl gerçekleştiğini sinir sistemi modeli üzerinde gösterebilir misiniz?
4. Her gözlemlenen olay için sinir sistemimizin hangi yapılarının mesaj iletimi sırasında ne görev yaptığını açıklayabilir misiniz?

Not: Bu kısımda öğrencilerin defterlerine sinirlerde uyarıların iletimini yazmaları sağlanır.

Sinir Sistemi Notları

Vücudun iç ve dış ortamla ilişkisini, organlar arasındaki bağlantıyı ve çalışma birliğini sağlayan sisteme sinir sistemi denir. Vücudumuzun bütün kısımlarının bir bütünlük içinde

çalışmasını ve çevremizle olan ilişkilerimizi (düşünme ,öğrenme vb..) sağlayan sistemdir. İnsanlarda sinir sistemi merkezi ve çevresel sinir sistemi olarak iki kısımda incelenir.

- a) **Merkezi sinir sistemi:** Düzenleyici sistemlerdir. Beyin, beyincik, omurilik soğanı ve omurilikten oluşur.
- b) **Çevresel sinir sistemi:** Merkezi sinir sistemi ile organlar arasında haberleşmeyi sağlayan sinirlerin oluşturduğu sisteme denir.

Merkezi Sinir Sistemi

BEYİN: Sinir sisteminin en büyük ve en karmaşık organıdır. Kafatası içinde bulunur, iki yarım küreden oluşmuştur. Üzeri girintili çıkıntılıdır. (1300-1500 gram-sinirlerin üçte ikisi burada bulunur). Beyin görevleri açısından Ön beyin, orta beyin ve arka beyin olmak üzere üç kısımdan oluşur.

Beynin Görevleri:

- 1-Göz, kulak, burun, dil, deri gibi duyu organlarımızla alınan uyarıları alır ve değerlendirir.
- 2-Kol, bacak ve yüz hareketleri gibi istemli hareketleri denetler.
- 3-Düşünme, öğrenme, hissetme, hatırlama, yazma, konuşma gibi yeteneklerimizin merkezidir (zekâ, irade, hayal kurma).
- 4-Acıkma ve susamayı düzenler.
- 5-Uyku ve uyanıklılık periyodunu ayarlar.
- 6-Vücut sıcaklığını ayarlar.
- 7-Hormonların salgılanmasını kontrol eder.

BEYİNCİK: Beynin arka tarafında, beyinle omurilik soğanı arasında bulunur.

- Kaslarımızın uyumlu biçimde hareket etmesinden ve vücudumuzun dengesinden sorumludur.
- Özellikle hızlı ve karmaşık hareketler ile yürüme, yazma ya da dikiş dikme gibi öğrenilmiş hareketlerin yönetilmesinde beyine yardımcı olur.
- Kulaktaki yarım daire kanallarından aldığı mesajlara göre vücudun dengesini sağlar.

- Beyincikte iki yarım daireden oluşur. Ama yüzeyi beyin kabuğu gibi kıvrımlarla değil, incecik kırışıklarla kaplıdır.
- Beyincikte vücudun değişik bölümlerini denetleyen belirli alanlar vardır. Gözleri hareket ettiren kaslarda beyinciğin denetimindedir.

OMURİLİK SOĞANI:

- Şekli soğana benzediği için bu isimi almıştır. Omuriliğin üst kısmında beyinciğin altında bulunur. Omurilik ile beyin arasındaki sinirsel bağlantıyı sağlar.
- Beynin tam tersine İçinde boz dışında ak madde bulunur. Üzeri beyin zarı ile örtülüdür.
- Beyinden vücuda yayılan birçok sinirin geçit yeridir.
- Solunum, boşaltım, sindirim, dolaşım, üreme gibi olayları yapısındaki sinir merkezleri ile düzenler.
- Solunum, hapşırma, öksürme, tükürük salgılama, yutma, kusma, çiğneme, kalp atışı, kan damarlarının büzülmesi gevşemesi gibi birçok refleks olayının kontrol merkezidir bu yönüyle **hayat düğümü** olarak ta adlandırılır. Omurilik soğanının zedelenmesi ölümle sonuçlanan tehlikeli durumlara yol açar (Bitkisel hayat).

OMURİLİK:

- Omurga kanalı içinde boydan boya uzanan bir sinir demetidir. Bütün sinirler omurilikten çapraz olarak çıkar.
- Omurilik; alıcı organların mesajlarını beyne, beyinden gelen emirleri de hareket organlarına iletir.
- Beynin sol tarafından çıkan sinirler sağ tarafa, sağ tarafından çıkan sinirler sol tarafa gider (31 çift sinir).
- Beynin sol tarafı vücudun sağ tarafını, sağ tarafı da sol tarafını idare etmektedir.
- Omurilik ayrıca bazı refleksleri kontrol eder alışkanlık hareketlerini denetler.

Refleks: Çevreden aldığımız uyarılara istem dışı (otomatik olarak gösterdiğimiz ani tepkilere) denir. Refleks korunma amaçlı olarak yapılır. İstemsiz bir harekettir. Kazanılma şekline göre iki çeşit refleks davranışı bulunur.

1-Doğuştan kazanılan(kalıtsal) refleks: kişinin genleri ile ilgili olup bütün insanlarda bulunur. İğne batan elin çekilmesi, diz kapağına vurulduğunda ayağın

hareket etmesi, ışık etkisi ile göz bebeklerinin büyümesi ya da küçülmesi, doğan çocukların emme davranışı, hapşırma davranışları örnektir.

2-Sonradan kazanılan (şartlı) refleks: Yaşanılan deneyimler sonucu öğrenilerek kazanılır. Sadece deneyimi yaşayan insanlarda bulunur. Limon görüldüğünde ağzın sulanması, bisiklet ya da araba sürme, örgü örme, piyano çalma ve dans etme davranışları örnektir. Ancak piyano çalarken hata yapılırsa beyin devreye girer ve hatayı düzeltir.

Çevresel sinir sistemi:

Merkezi sinir sistemini oluşturan organların dışında yer alan milyonlarca sinir, çevresel sinir sistemini oluşturur. Merkezi sinir sistemi ile organlar arasındaki iletişimi sağlar.

SİNİRLER VE SİNİRLERDE UYARININ İLETİMİ

İstemli ve istemsiz bütün hareketlerin uyarıları sinirler tarafından taşınır. Sinirler, sinir merkeziyle duyu organlarını ve kasları birbirine bağlayan beyazımsı kordonlardır.

- Sinir hücrelerine **nöron** denir. Nöronlar iki ayrı kısımdan oluşur.
- Bunlar **hücre gövdesi** ve uzantılarıdır. Hücre gövdesinde çekirdek ve sitoplazma bulunur. Uzantılar kısmı **uzun uzantı (akson)**, **kısa uzantı (dendrit)** olarak ikiye ayrılır.
- Nöronlarda birçok dendrit bulunmasına rağmen sadece bir tek akson vardır.
- Uyarılar dış çevreden veya vücut içerisinden dendritler tarafından alınır. Eğer uyarı yeterince güçlüyse mesaj (impuls) oluşur.
- Mesajlar nöronlarda sadece bir yönde hareket eder. Dendritler bir mesajı alır hücre gövdesine götürür, Aksonda mesajı hücre gövdesinden dışarı taşır.
- Birinci nöronun aksonu ikinci nöronun dendriti ile temas etmez. Bir nöronun aksonu ile diğer nöronun dendriti arasındaki boşluğa **sinaps** denir.

Mesajın iletimi: Mesajlar sinirler boyunca elektriksel ve kimyasal enerji ile hareket eder.

- Bir mesajı sinapsa getiren elektrik enerjisi sinapsta kesilir. Burada akson tarafından belirli kimyasal maddeler salgılanır.

- Kimyasal maddeler mesajı aksondan alarak yolu üzerindeki diğer nörona iletir.
- Böylece gönderici nörondan çıkan mesaj alıcı nöronun dendritine ulaşmış olur.
- Daha sonra elektriksel enerji tekrar devreye girer ve aynı işlemler mesaj gideceği yere ulaşincaya kadar tekrarlanır.

Üç tür nöron vardır.

- **Duyu nöronları;** Mesajları duyu organındaki duyu alıcılarından omuriliğe ve beyne taşır.
- **Hareket nöronları;** Mesajları omurilik veya beyinden kaslara ve bezlere taşır.
- **Ara nöronlar;** Mesajları duyu nöronları ve hareket nöronları arasında taşır. Ara nöronlar omurilik ve beyinde bulunur.

SİNİR SİSTEMİNİN SAĞLIĞI

Sinir sistemindeki bozukluklar iç organların çalışmasını da olumsuz yönde etkiler. Sinir sistemimizin sağlığı için düzenli uyku uyumalı, dengeli beslenmeli, temiz havalı yerlerde gezmeli, alkol ve uyuşturucudan uzak durmalı yaşamıza uygun spor yapmalıyız. Sinir hücrelerinin çoğunda, vücut hücreleri gibi kendini yenileme ve onarma özelliği yoktur. Bu yüzden özellikle beyin ve omurilikte sinir dokusunun zedelenmesi çoğu zaman kalıcıdır. Çarpma, vurma gibi durumlarda sinir hücreleri zedelenir ve kısmi veya genel felç durumları ortaya çıkar. Sinir sistemi zedelenen insanlarda kontrolsüz hareketler, titreme, katılaşma, öğrenme güçlüğü, hafıza kaybı gibi durumlarda ortaya çıkar.

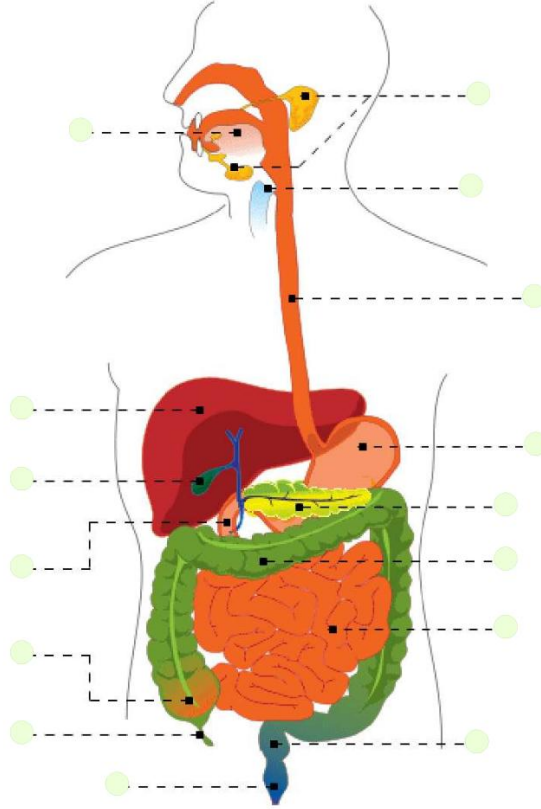
C) Small Group Activity Worksheets prepared by Mrs. Celin

Small group activity 1: ‘Why do we eat?’

Neden Besleniriz?

Grup Adı

Tarih



- ✓ Yediğiniz besinler vücudunuzda kullanılır hale gelebilmesi için hangi yollardan geçer ve nasıl değişimlere uğrar? Bu soruyu yukarıdaki sindirim sistemimizi gösteren şekilden yardım alarak grubunuzla beraber cevaplandırınız ve düşüncelerinizi not alınız.

Daha sonra grubunuzun ulaştığı sonucu 1-2 dakikalık bir sunum ile sınıfta açıklayınız.

Besin İçeriklerinin İnsan Vücudundaki Seyahati

Grup Adı

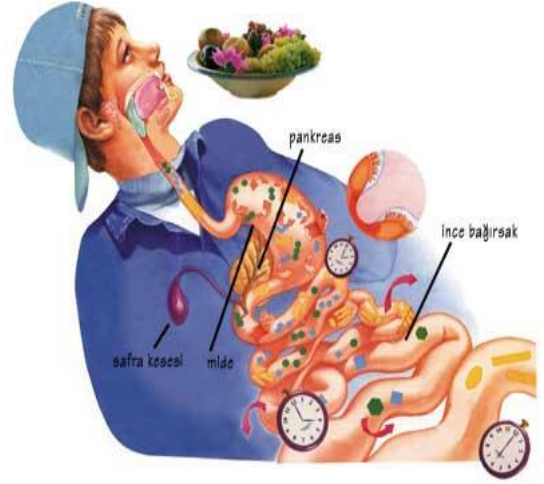
Tarih

Besin maddelerinin içeriklerine göre karbonhidrat, yağ, protein, vitamin, su ve mineraller olarak gruplandırıldığını biliyoruz. Daha önceki dersimizde bu besin içeriklerinin vücudumuzda enerji üretmek, yapım-onarım için ve düzenleyici olarak kullanıldığını öğrenmiştik.

Besin içerikleri büyük moleküllerdir. Büyük molekülü besin içeriklerinin hücrelerimizin kullanabileceği kadar küçük moleküllere parçalanması gerekir. Yediğimiz besinler hücrelerimize geçebilecek duruma sindirim işlemi sonucunda gelir. Öyleyse vücudumuzda farklı besin maddelerinin sindirimi nasıl gerçekleşir? Bu sorunun cevabını bulmak için grubumuzla birlikte aşağıdaki etkinliğimizi yaparak öğrenelim.

Bunları Yapalım

- ✓ Besin gruplarından 2 tanesini araştırmamız için seçerek, bu besin gruplarının her birine birer örnek verelim.
- ✓ Sindirim sistemi modelini ve diğer şekilleri inceleyerek örnek olarak verdiğimiz bu besinlerin vücudumuzda sindiriminin nasıl gerçekleştiğini diğer grup üyeleri ile birlikte açıklayalım.



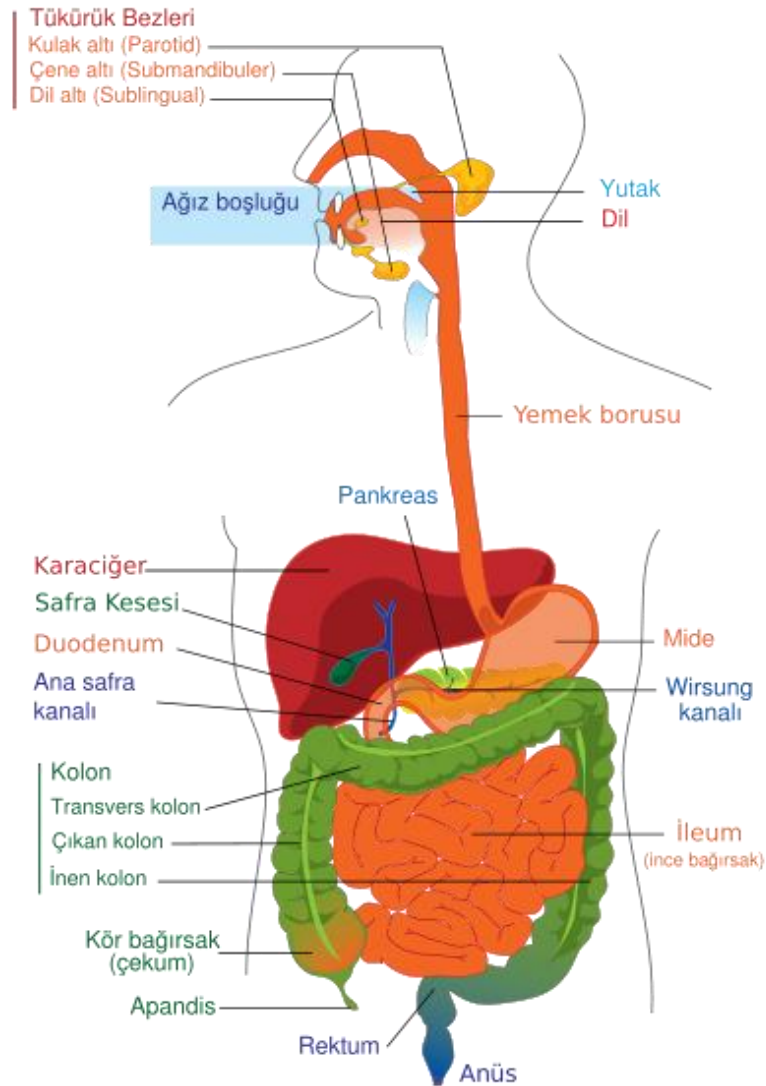
Daha sonra aşağıdaki soruları cevaplar arayalım ve cevaplarımızı grup üyelerimizden birisinin not almasını sağlayalım.

Sonuca Varalım

- ✓ Seçtiğimiz besinlerin sindirim sistemimizin hangi bölümlerinde fiziksel ve kimyasal sindirime uğradığını söyleyebilir misiniz?

- ✓ Sindirime yardımcı hangi organlardan salgılanan enzimler seçtiğimiz besinlerin kimyasal sindiriminde nasıl ve sindirim sistemimizin hangi kısımlarında görev yapmaktadırlar?
- ✓ Seçtiğimiz besinler hangi yapıtaşlarına kadar dönüştürülürler ve dolaşım sistemimize hangi yapı sayesinde ve sindirim sistemimizin hangi kısımlarından geçerler?
- ✓ Seçtiğimiz besinlerin sindirimi sonucu oluşan ürünler kan yolu ile nerelere taşınır ve ne amaçla kullanılırlar? Açıklayınız.

Sindirim Sistemi Modeli



Futbol Maçı

İsim

Tarih

Sizce vücudumuzda gerçekleşen olayların düzenli ve birbiriyle uyumlu bir şekilde gerçekleşmesini sağlayan şey ne olabilir? Bu sorunun cevabını aşağıdaki etkinliğimizi yaparak öğrenelim.

Futbol maçı sırasında futbolcuların vücudunda ve çevrelerinde fark edebileceğimiz kaç olay gerçekleşir? Bu sorunun cevabını bulmak için grubumuzla birlikte aşağıdaki işlemleri yapalım.

Bunları Yapalım

- ✓ Futbol oynayan iki takımı gösteren video klipimizi hep beraber izleyelim, ve futbolcuların vücutlarında veya çevrelerinde kaç olay gerçekleştiğini belirlemeye çalışalım. Belirlediğimiz bu olayları defterlerimize liste hâlinde yazalım.
- ✓ Listelerimizi sırayla okuyalım. Ardından gruptaki bütün üyelerin belirledikleri olayları içeren yeni bir liste oluşturalım.
- ✓ Hazırladığımız listeden yararlanarak aşağıdaki soruları cevaplayalım ve cevaplarımızı grubumuzdan birisinin not almasını sağlayalım.



Sonuca Varalım

1. Futbol oynayan bir kişinin vücudunda ve çevresinde kaç olay meydana gelmektedir?
2. Bu kişinin vücudunda ve çevresinde, futbol oynarken gerçekleşebilecek olay sayısı sadece belirlediğimiz kadar mıdır? Tartışalım.
3. Bu olayların her biri vücudumuzdaki hangi sistem veya sistemler tarafından gerçekleştirilir?
4. Bu olayları gerçekleştiren sistemler birbirlerinden bağımsız olarak mı çalışır?
5. Vücudumuzda bu kadar çok sayıda olay, birbirini engellemeden nasıl gerçekleşebiliyor?

Zehirli Bitki Grup Çalışması

Grup Adı

Tarih

Sinir sisteminin canlıların içsel ve dışsal çevresini algılamasına yol açan, bilgi elde eden ve elde edilen bilgiyi işleyen, vücut içerisinde sinir hücreleri ağı sayesinde sinyallerin farklı bölgelere iletimini sağlayan, organların, kasların aktivitelerini düzenleyen ve birbiri ile iletişim kurmasını sağlayan bir sistem olduğunu bir önceki etkinliğimizde öğrenmiştik.

Peki bu olayların gerçekleşmesi sırasında, sinirlerde mesaj iletiminin nasıl olduğunu hiç düşündük mü? Bu sorunun cevabını aşağıdaki etkinliğimizi yaparak öğrenelim.

Vücudumuzun içerisinde ve dışarısında algıladığımız değişikliklere belli bir düzen ve kontrol içinde cevap veririz. Sinir sistemimiz bu değişikliklerin bazılarını bilinçli ve kontrollü bir şekilde cevap verirken, bazılarını bilincimiz dışında otomatik olarak cevap vermektedir.

Birazdan izleyeceğimiz video klipteki futbol oynayan kişinin sinir sisteminin hangi değişikliklere, nasıl cevap verdiğini açıklayabilir misiniz?

Bu sorunun cevabını bulmak için grubumuzla birlikte aşağıdaki işlemleri yapalım.

Bunları Yapalım

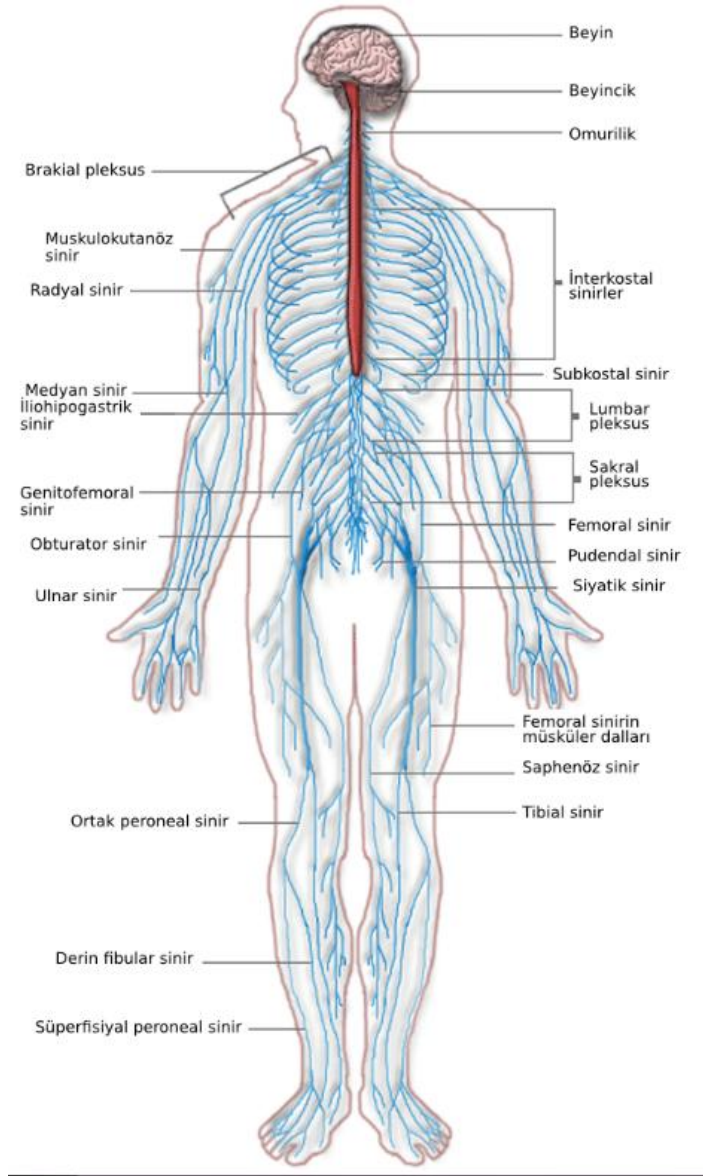
- ✓ Grubumuzla beraber futbol oynayan çocukları gösteren video klipimizi hep beraber izleyelim, ve kaleci olarak görev yapan kişinin sinir sisteminin gerçekleştirdiği olayları gözleyelim, ve gözlemlerimizi defterlerimize kaydedelim.
- ✓ Gözlemlerimizi grup içinde sırayla okuyalım. Ardından grup olarak üzerinde anlaştığımız gözlemlenen olayları içeren bir liste oluşturalım.
- ✓ Bu gözlemlenen olayları düşünerek aşağıdaki soruları cevaplayalım ve cevaplarımızı grubumuzdan birisinin not almasını sağlayalım.

Sonuca Varalım

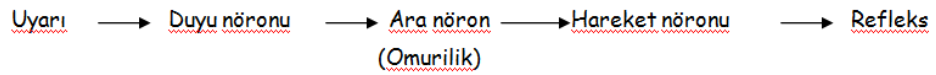
1. Mac sırasında kalecilik yapan çocuğun sinir sisteminin cevap oluşturduğu olaylar hangileridir? Bu olayların her biri hangi sistem ya da sistemler tarafından gerçekleştirilir?
2. Bu olaylardan hangilerini kaleci çocuk bilinçli olarak kontrol edip, hangileri otomatik olarak gerçekleşmiştir? Grubumuz içinde tartışalım.

3. Gözlemlediğiniz olaylar sırasında sinirlerde mesaj iletiminin nasıl gerçekleştiğini sinir sistemi modeli üzerinde gösterip açıklayabilir misiniz?
4. Her gözlemlenen olay için sinir sistemimizin hangi yapılarının mesaj iletimi sırasında ne görev yaptığını açıklayabilir misiniz?

Sinir Sistemi Modeli



Refleks yayı



Vücutumuzun Su İçeriği

Grup Adı

Tarih

Bir önceki konumuzda vücut koşullarında değişiklik meydana gelmesi durumunda, bu değişikliğin vücutumuz tarafından otomatik olarak algılanıp ve uygun bir tepki oluşturulduğunu öğrenmiştik. Şimdiki konumuzda ise boşaltım sistemimizi oluşturan yapı ve organları ve bunların görevlerini inceledik. Böbreklerimizin kanımızı süzerek kanımızın içindeki yararlı maddeleri koruyup atık maddeleri uzaklaştırdığını öğrendik.

Sizce bu iki konu arasında nasıl bir ortak nokta olabilir? Vücutumuzda kanımız nasıl temizlenir ve bu işlem sırasında kanımızdaki su içeriği nasıl düzenlenir? Bu soruları cevaplandırmak için grubumuzla birlikte aşağıdaki etkinliği yapalım.

Böbreklerimiz vücutumuzun çeşitli faaliyetleri sonucunda oluşan atık maddeleri kanımızdan süzerek uzaklaştırır. Kanımızda atık maddelerin yanı sıra karbonhidratların, yağların ve proteinlerin sindirilmesi sonucunda oluşan küçük moleküller ile vitamin ve su gibi yararlı maddeler de bulunur.

Öyleyse, böbreklerimizin kanımızı süzerken kanımızın içindeki yararlı maddeleri koruyup atık maddeleri uzaklaştırması gerekir. Kanımızdaki su miktarının belli seviyede kalması vücut hücrelerimizin doğru bir şekilde fonksiyonlarını yerine getirebilmeleri için önemlidir.

- ✓ Kanımızdaki su içeriğinin düzenlenmesinin ve böbreklerde kanın temizlenmesi işleminin nasıl gerçekleştiğini açıklayabilir misiniz?
- ✓ Bu işlemler gerektiği gibi gerçekleşmez ise ne gibi problemler ile karşılaşırız?



Bu soruların cevabını araştırmak için grubumuzla birlikte aşağıdaki işlemleri yapalım.

Bunları Yapalım

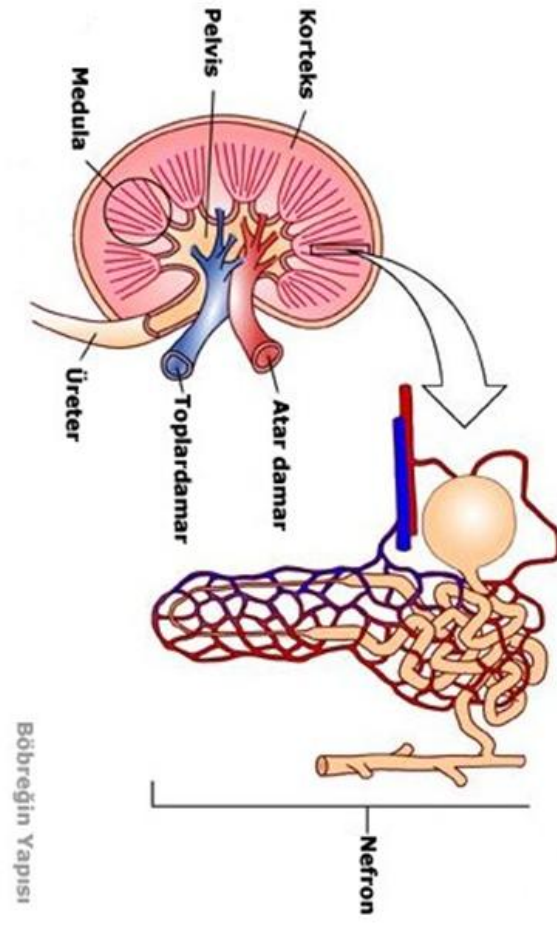
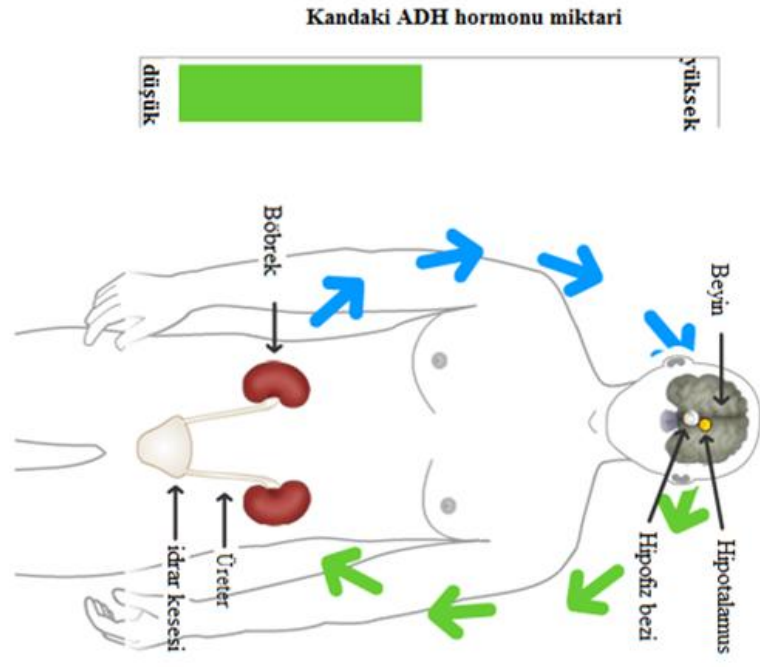
- ✓ Grubumuzla beraber şekil 1, 2 ve 3'te gösterilen diyagramları inceleyerek kanımızda yüksek ve düşük su miktarı seviyelerinde meydana gelen olayların neler olduğunu tahmin edelim ve düşüncelerimizi not alalım.
- ✓ Şekil 4'te gösterilen böbrek semasını inceleyerek kanımızın süzülmesindeki organ ve yapıları gösterip, görev ve işlevlerini grubumuzdaki arkadaşlarımız ile tartışalım.
- ✓ Daha sonra aşağıdaki soruları cevaplar arayalım ve cevaplarımızı grup üyelerimizden birisinin not almasını sağlayalım.

Not:

- ✓ Hipotalamus, beynin hormon üretebilen özelleşmiş bir bölgesidir. Kendisine komşu olan hipofiz bezi üzerinde durdurucu veya salgılatıcı etkiler meydana getirir.
- ✓ Anti-Diuretic hormon (ADH) hipofiz bezi tarafından salgılanır ve vücut su miktarı seviyesini kontrol etmemizi yardımcı olur.

Sonuca Varalım

1. Kandaki su miktarı seviyesi yükseldiğinde vücudumuz bunu nasıl algılar ve nasıl normal seviyesine getirir (semadaki organ ve dokuların bu işlemler sırasındaki rollerini açıklayalım)?
2. Kanımızdaki düşük su miktarı seviyesi vücudumuz tarafından nasıl algılanır ve vücudumuzun su kaybı nasıl önlenir (semadaki organ ve dokuların bu işlemler sırasındaki rollerini açıklayalım)?
3. Kanımızın süzülmesi sırasında böbreklerimizde hangi işlemler gerçekleşir?
4. Kanımızda süzülmeden sonra konsantrasyonu (yoğunluk seviyesi) değişen maddelere örnek verebilir misiniz? Bu maddelerin konsantrasyonun neden değişir? Tartışınız.



Appendix D – Semi-structure interview protocol

Scientific inquiry unit

- As you know, you are currently studying the human body system unit. What do you think about the inquiry activities being carried out in your science lessons?
- Can you explain why you are learning these science topics?
- Do you think that learning about science is meaningful and useful for you?
- What was the most interesting thing you like during science lessons? Why?

Small group activities

- How did you form your group?
- How and why do you think that the group work is important for your learning?
- How did you benefit from working in a group?
- What do you think about the role of teacher during the group activities?
- How did you interact with the teacher during group activities?
- What is your role(s) within your group?
- Why do you think that you are important for your group's functioning?

Appendix E – Sample information sheets and consent forms

SAMPLE TEACHER INFORMATION SHEET

REC Protocol Number: REP (EM)/09/10-35

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of study: Investigating the Turkish primary school students' regulation of learning processes during inquiry learning in science classrooms.

Dear Teacher,

I would like to invite you to participate in this postgraduate research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

The aim of this research project is to investigate the primary school students' regulation of learning processes during inquiry learning in science classrooms. Your participation in this project will be valuable in understanding how and why students attempt to regulate their learning and how their science teacher supports their regulation of learning during science lessons. The results of this research project could determine the features of students' regulatory behaviour and teachers' scaffolding that can help science teachers improve their teaching and students' learning.

If you choose to take part, I will be attending some of your ordinary science lessons to observe some target students. You will be invited to semi-structured and stimulated recall interviews where you will be asked to discuss with the researcher about your interactions with the target students while watching videotapes episodes of yourself teaching in the classroom. All interviews will take place on school premises after each science lessons observed and will last about 20 minutes. Furthermore, whole class video recordings of science lessons focusing on target students and whom they interact with will be also collected. Target students and your discourse will be also audio-recorded to support the video recordings. In addition, this research will require target students to participate in semi-structured and stimulated recall interviews that will focus on their regulation of learning processes during science lessons. These interviews will take place after each science lesson observed on school premises and will last about 20 minutes. The school administration is informed and willing to participate in this research project.

I would like to assure that you will not be exposed to any kind of risks during the project and all necessary measures will be provided for anonymity and confidentiality. The interviews will be audio recorded but only the researcher will listen to the recordings of the interviews. Written examples of the interviews may be shared with other researchers, but you will be completely anonymous. Only the researcher and his supervisors will have full access to the videos and audio-recordings from your science lessons. However, during their interviews, some of your students will be able to only see some of the videotapes episodes of yourself which will not harm you in any way. Only the researcher will be able to connect the data to your school. Your name will be removed from any sample of your work.

If you wish further information, please contact me via email sekan.ucan@kcl.ac.uk or at 0044 7503 40 6463. It is up to you whether you participate or not. If you do agree to participate, please keep this information sheet and sign the consent form provided. Please be aware also that if you decide to give permission, you are still free to withdraw from the research project without giving a reason approximately until December 2010 that the data collection process is to be completed. Finally, if this study has harmed you in any way you can contact King's College London using the details below for further advice and information:

Prof. Peter Kutnick

Department of Education and Professional Studies, King's College London,
Rm 1/14, Franklin-Wilkins Building, London SE1 9NH, United Kingdom, 0044 207 8484420,
peter.kutnick@kcl.ac.uk

SAMPLE PARENTS IFORMATION SHEET

REC Protocol Number: REP (EM)/09/10-35

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of study: Investigating the Turkish primary school students' regulation of learning processes during inquiry learning in science classrooms.

Dear Sir/ Madam,

I would like to ask for permission for your child to participate in this postgraduate research project. You should allow your child to participate only if you want to; choosing not to take part will not disadvantage him/her in any way. Before you decide whether to give permission, it is important for you to understand why the research is being done and what your child's participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

The aim of this research project is to investigate the primary school students' regulation of learning processes and their teachers' influences on these processes during inquiry learning in science classrooms. Your child's participation in this project will be valuable in understanding how and why they attempt to regulate their learning and how their science teacher supports their regulation of learning during science lessons. The results of this research project could determine features of students' regulatory behaviour that can help students learn science better.

If you choose to give permission, I will be attending some of your child's science lessons to observe the learning activities of some target students whom will be randomly selected by their science teacher. This research will require these target students to participate in semi-structured and stimulated recall interviews where they will be asked to discuss with the researcher about their interactions with their teacher and other students while watching videotapes episodes of them working in the classroom. These interviews will take place after each science lesson observed on school

premises and will last about 20 minutes. Furthermore, whole class video recordings of science lessons focusing on target students and whom they interact with will be also collected. These target students' discourse will also be audio recorded during the science lessons observed in order to support the video recordings. Your child's teacher is informed and willing to participate in the project.

I would like to assure you that your child will not be exposed to any kind of risks during the project and all necessary measures will be provided for anonymity and confidentiality. The interviews will be audio recorded but only the researcher (me) will listen to the recordings of the interviews. Only the researcher and his supervisors will have full access to the videos and audio-recordings from your child's science lessons. However, during their interviews, your child's science teacher and some of his/her classmates will be able to only see some of the videotapes episodes which will not harm your child in any way. Written examples of the interviews may be shared with other researchers, but your child will be completely anonymous. Only the researcher will be able to connect the data to your child's school. Your child's name will be removed from any sample of their work.

If you wish further information, please contact me via email sekan.ucan@kcl.ac.uk or at 0044 7503 40 6463.

It is up to you to decide whether to allow your child to participate or not. If you decide to consent to your child participating, please keep this information sheet and sign the consent form provided. Please be aware also that if you decide to give permission, your child is still free to withdraw from the research project without giving a reason approximately until December 2010 that the data collection process is to be completed.

Finally, if this study has harmed your child in any way you can contact King's College London using the details below for further advice and information:

Prof. Peter Kutnick

Department of Education and Professional Studies, King's College London,

Rm 1/14, Franklin-Wilkins Building, London SE1 9NH, United Kingdom, 0044 207 8484420,
peter.kutnick@kcl.ac.uk

PARENTS CONSENT FORM

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: Investigating the Turkish primary school students' regulation of learning processes during inquiry learning in science classrooms.

King's College Research Ethics Committee Ref: *REP (EM)/09/10-35*

Dear Sir/Madam,

Thank you for considering allowing your child to participate in this research. The information sheet accompanying this consent form includes all the information relating to the project. However, if you have any questions arising from that, please do not hesitate to ask the researcher (Serkan Ucan) before you decide whether to give consent. You will be given a copy of this Consent Form to keep and refer to at any time. Please note that confidentiality and anonymity will be maintained and it will not be possible to identify your child from any publications.

I understand that if I or my child decides at any time during the research that no longer wishes to participate in this project, I or my child can notify the researchers involved and my child will be withdrawn from it immediately.

I consent my child to be audio and video recorded during the science lessons observed, and audio recorded during the interviews carried out in this research study.

I consent to the processing of my child's personal information for the purposes of this research study. I understand that such information will be treated in accordance with the terms of the Data Protection Act 1998.

Guardian's Statement:

I _____

agree that the research project named above has been explained to me to my satisfaction and I agree to let my child _____ take part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Please circle your relationship to the child named above:

Father Mother Guardian Other.....

Signed _____

Date _____

Please return this consent form to your child's science teacher.

Thank you.

SAMPLE STUDETNS IFORMATION SHEET

REC Protocol Number: REP (EM)/09/10-35

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of study: Investigating the Turkish primary school students' regulation of learning processes during inquiry learning in science classrooms.

Dear student,

I would like to ask you to take part in my research project. Please read this information leaflet before you decide.

You should only accept to participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether to give permission, it is important for you to understand why the research is being done and what you will have to do. Please take time to read the following information carefully and discuss it with others if you wish. Ask me or science teacher if there is anything that is not clear or if you would like more information.

This is what I want to do:

This project aims to explore the ways students learn and how science teachers support students' learning processes during science lessons. By means of this research project, we can find ways of helping you learn science better.

To do that, I will come into your classroom and observe science teaching and learning activities. I will video record some of your science lessons focusing on some of you. I would also like to interview some of you. This interview will take place on school premises after each science lesson and will last about 20 minutes. During this interview, I will ask some questions about your learning activities while watching videotapes episodes of yourselves working in the classroom. Finally, I would like to audio-record some of you, as you talk during the science learning activities.

Your science teacher has also agreed to participate in the project.

You will not be assessed on the answers you give during the interviews. The interviews will be audio recorded but only the researcher (me) will listen to the recordings of the interviews. Your name will be removed from any sample of your work I might use. Only my supervisors and I will have full access to the videos and audio-recordings from your science lessons. However, during their interviews, your science teacher and some of your classmates will only be able to see some of the videotapes episodes which will not harm you in any way. If you like more information, please contact the researcher, Serkan Ucan (serkan.ucan@kcl.ac.uk). Please be aware that if you decide give permission, you are still free to withdraw from the research project without giving a reason approximately until December 2010 that the data collection process is to be completed.

If you do agree to participate, I need you to sign the form below.

Finally, if this study has harmed you in any way you can contact King's College London using the details below for further advice and information:

Prof. Peter Kutnick

Department of Education and Professional Studies, King's College London

Rm 1/14, Franklin-Wilkins Building, London SE1 9NH, United Kingdom

0044 207 8484420, peter.kutnick@kcl.ac.uk

Appendix F - Transcriptions of the episodes in the Figures 4.7, 4.8 and 4.9

Sequence of episodes for Figure 4.7

- 1 Ay: I still don't understand how this [video] is related to this subject.
- 2 L: Um (*thinking and looking at Ayse*).
- 3 K: May I read the first questions?
- 4 L: First question, yes (*nodding*).
- 5 K: 'How many events can occur around and inside a person's body who is playing football?' Can I answer this?
- 6 Ay + L: Yes (*nodding*).
- 7 K: Now, first of all, there are physical events, such as running. And there are also mental events (*pointing at his brain*). Those are reasoning, because football requires reasoning. If you don't have, you cannot be successful. So they are using physical, but also mental processes. There are 3 types of events happening around and inside a footballer's body. First is physical, running, second is mental, thinking, and the third one is passing the ball. Um sorry it is actually two (*smiles*).
- 8 L: What about you (*Ayse*)?
- 9 Ay: I agree that there are two types.
- 10 L: I think, there are actually three types of events.
- 11 K: So, tell us?
- 12 L: Firstly, there is physical such as running and defending, and there is a reflex one, as they are trying to keep the ball. There is also a neural event, as they are thinking and playing.
- 13 K: I think just two,
- 14 L: Actually, in my opinion, as we have watched in this video, when a few rival footballers approach,
- 15 Ay: It is physical, isn't it?
- 16 L: A need emerges to pass the ball more quickly.
- 17 K: So accordingly, there should be three types of events. We have said reflex, physical and mental.
- 18 L: For instance, when scoring a goal if you are good enough (*looks at her partners*), there is a reflexive event, and then there is also a physical one (*takes a note*).

- 19 Ay: Leman, scoring a goal is not a reflexive event. How can we score with our reflexes?
- 20 L: No, what I mean by scoring is (*smiles*), for example, when there is no one in the goal area you can try to score. Or you are the goalkeeper, so it can be also keeping the ball (*uses specific hand gesture while explaining*). OK?
- 21 Ay: No, this event is actually physical. Do you jump suddenly as a goalkeeper when the ball comes (*shows how to jump*)?
- 22 K: Yes, it is a reflex (*glances at his partners*).
- 23 L: Yes.
- 24 Ay: No, it is not, one moment. When someone approaches, you either keep the ball,
- 25 K: Pass the ball.
- 26 Ay: Or pass the ball.
- 27 L: Yes, OK but...
- 28 Ay: This actually becomes a mental process (*speaks to Leman*). When someone sees the goal area empty, he doesn't pass the ball as a neural event. So, there is nothing like scoring a goal with a reflex.
- 29 T: (*she approaches to the group*) Alright, what else happens, running, sweating?
- 30 K: They are physical.
- 31 Ay: Physical.
- 32 K: Should we look at the next question?
- 33 L: No Kutay (*with a loud sound*). Now, we have talked about three types of events, neural, physical and mental.
- 34 All: (*continue to take notes*)
- 35 K: But, um, what is this [word], neural or digestive? (*pointing at Leman's notebook while looking confused*) {*In Turkish, "sindirim" means digestive and "sinirsel" means neural, so the initial letters of these words are the same and hence could be confused*}
- 36 L: Don't be silly, Kutay! (*taking a deep breath while leaning back and forward and speaking in a bored tone of voice*)
- 37 K: Leman, I can't read it! (*eyebrows are lowered and the volume of his voice rises while leaning back away from the desk*)
- 38 L: How can it be "digestive"? (*stares at Kutay*)
- 39 K: But it starts with an 'S', what else can it be? (*looks upset*)
- 40 L: Of course it is 'neural', we are working on the nervous system now (*speaking in a bored tone of voice*).

41 K: There is no such thing as neural, it is called reflex (*looks at both Leman and Ayse with a sad facial expression*).

42 L: (*looks at Ayse*)

43 Ay: Neural? Are we really going to say neural is reflex (*confused look*)?

44 K: Yes, you will write reflex. Look, Leman, when we think about neural events, we refer to the nervous system, but only reflex is involved here (*staring at Leman with a negative frowning expression and playing with his pen constantly*).

45 L: Kutay, at the moment, none of us know the correct answer, anyway (*looks at K and speaks with a furious tone of voice*).

46 K: OK, Leman, humph! You are always the right one, anyway (*raises his shoulders while looking at his notebook and speaking in a low tone of voice*) (*glances at L*).

47 L: I want to do this way (*stares at K*).

48 K: OK, I want to do my own way too (*pointing at his notebook*).

49 L: So, don't interfere with me (*starts writing*).

50 K: OK (*looks very upset*).

51 Ay: Leman, but we are working as a group (*looks at L and speaks in a calm tone of voice*).

52 L: Ok, but didn't we agree on neural events at the beginning? (*speaks in a calm tone of voice*).

53 Ay: But Kutay is also talking about reflex too. I am writing his idea in parenthesis now (*writing K's suggestion on her notebook*).

54 K: I am writing it in parenthesis too (*speaks in a calm tone of voice*) (*writing*).

55 L: When I say neural events, I also think about reflex. That's why I have said so (*looking at K*).

56 L: (*After a few seconds of silence*) let's give an example for mental events too (*looking at Ay*).

57 Ay: Something like defending. Can we call it mental?

58 K + L: (*no response from either of them*)

59 L: Should we read the next question?

60 Ay: Yeah.

61 L: So, "Is the number of events that occur while playing football limited to what we have identified?" We can classify them under three different headings. But if we write everything one by one, we can get many things.

62 Ay: Yes.

63 K: Sorry, I can't understand what you are speaking.

64 Ay: We have said, one second. Leman, can you tell? He can hear you better.

65 K: Everyone is shouting, I cannot hear well,
 66 L: Now, we can sum up these events under three different topics, but we can
 augment the examples for each of them.
 67 K: I see.
 68 L: As being physical for instance, someone playing football can drink water, move
 around and run. Being mental, we have already said defending. And as neural they
 have reflexes.
 69 K: Yes alright.
 70 K: Next question, Ayse.
 71 L: Ayse, can you read the next question?
 72 Ay: Which system or systems in our body perform each of these events?
 73 T: *(she is listening to the group conversation and standing next to Kutay)*
 74 K: Reflex is being performed by the nervous system.
 75 Ay: Yes *(nodding)*.
 76 L: Nervous system.
 77 K: For physical events, I think, our cells are involved. Because we need energy and
 we supply our energy through mitochondria which is in our cells.
 78 L: It is the skeletal system *(while writing, she raises her head and looks at*
Kutay).
 79 K: Sorry *(pays attention to Leman)*?
 80 L: Skeletal system.
 81 K: Yeah, possibly *(with a puzzled face)*. Teacher, isn't the energy provided by our
 cells *(smiles and talks to the teacher with a hesitant tone of voice)*?
 82 T: Yes.
 83 K: OK.
 84 T: But we are talking about systems not cells.
 85 K: Yes, right, skeleton system *(looks confused and displeased - he touches his chin*
with his left hand and puts his pen into his mouth).
 86 T: *(she leaves the group)*
 87 K: So, which one is performing the mental events *(turns back and checks if the*
teacher is still listening to them)?
 88 Ay: I think it is our brain.
 89 L: In my view, this can be included in the nervous system.
 90 Ay: In the nervous system? I think, it is not very much associated with the nervous
 system.

- 91 K: Because the brain is already a thinking system.
92 Ay: because it is not something we feel, like moving.
93 L: But, aren't cerebral events in the nervous system? The events our brain carries out.
94 Ay: What I understand from the book and as we have talked, nervous system is not about cerebral events, I mean...
95 L: So which system can we write for cerebral events?
96 Ay: I think it is not system. It is just a brain.

Sequence of episodes for Figure 4.8

- 1 E: Now, third question. Brus can read. I have read the previous one (*glances at Brus*),
2 B: It asks us to describe and explain the events we observed on the nervous system model (*looking at his partners and pointing at the diagram*)
3 V: There are two events,
4 E: Yes. Should we explain only one event (*glances at her partners*)?
5 V: Well, you are the group leader (*glances at E*),
6 E: Teacher (*raises her hand and speaks with a loud tone of voice*)?
7 B: Well, I am the class president (*glances at V*),
8 V: But she is the group leader (*smiles*),
9 T: (*Approaches to the group*)
10 E: Can we explain only this event (*glances at her teacher and points at her notes*)?
11 T: Now, what is the most evident incident you have observed (*glances at E*)?
12 E: Neurons are stimulated, when the kid touches the poisoned plant (*looks at her notes*),
13 T: Pulling his hand away?
14 B: Yes, it sends a signal to the spinal cord,
15 T: Ok (*nodding*), you can try to explain this [incident] by considering the reflex arc. You should explain what happens first, where the stimulus goes, where the response is created, and what the reaction is (*looks at all group members*)?
16 E: Yes, ok (*starts writing on her notebook*)
17 V: Ezgi, do you really have the ability to draw (*glances at her and makes fun of her*)?
18 T: You don't need to draw. You can explain it by using that reflex arc (*pointing the lesson book*).

19 V: I think, we can draw a small plant here and it [neural message] can come from
here to here (*showing on the model*),

20 E: If we write our explanation on the model, it can be better, such as coming from
spinal cord to here,

21 V: No, it doesn't go to the brain. It will return from there (*pointing at the spinal
cord*)

22 E: Um, but the thing. Yeah (*nodding*),

23 B: But doesn't it occur like this? The needle is broken here, so doesn't it [neuron]
come from here and goes to the brain? (*Showing on the model*)

24 V: No, it doesn't go to the brain. It actually happens automatically, as we talked
previously.

25 E: It is not going to the brain. Only going to this round thing (*pointing at the spinal
cord*),

26 B: But, when the ball comes, the brain is directly involved?

27 E: Yes, in this case, it goes to the brain.

28 T: Yes, kids, you have five minutes to finish your work,

29 E: Alright, let's look at the third question. Neuron cell, here, is this (*showing the
model*)?

30 V: We will draw,

31 E: Yes, we will just draw those, stimulus, sensory neurons and neurons,

32 V: Motor neurons,

33 B: neurons,

34 E: So what is next?

35 B: Actually, if there was a nervous system in the cars, this could be fantastic. Brakes
could be integrated with sensors,

36 E: neurons,

37 V: And reflex,

38 B: Sorry, I put this arrow into wrong place,

39 E: Next question,

40 B: We have only three minutes,

41 V: It is ok, no worries,

42 B: Fourth question,

- 43 E: I am reading the fourth question ‘During the events below, which parts of the nervous system are involved and what kind of tasks they carry out?’ (*Reading*)
- 44 E: When the kid touches his hand to the poisoned plant, pulls his hand away and screams,
- 45 V: Does he really scream?
- 46 E: He says “ah”,
- 47 B: Explain how and what tasks do they perform?
- 48 E: Let’s focus on this,

Sequence of episodes for Figure 4.9

- 1 K: Should we read the third question?
- 2 L: Ayse should read it. She hasn’t read any today,
- 3 Ay: I am reading, ‘*Please describe and explain the events you observed on the nervous system diagram.*’ (*Reading*)
- 4 L: It asks us to demonstrate on the diagram (*glances at her partners*),
- 5 Ay: This one is our model (*pointing the diagram*),
- 6 K: Yeah, this model,
- 7 L: Ah, ok, I thought we would draw another model,
- 8 K: We will first describe the events on this model and explain them. Then, we will write our explanations to our notebook (*looks at his partners*),
- 9 L: Let’s write the explanations here (*writing*)
- 10 Ay: Hang on Leman! Don’t study individually,
- 11 L: Ok,
- 12 T: Class, you have five minutes to finish your group work,
- 13 K: That’s cool! We can easily finish (*speaks with an encouraging tone of voice*).
- 14 K: Now, it [*poisoned plant*] touches this tissue here. So as we explained, the stimulus goes to spinal cord by means of neurons, from spinal cord to spinal bulb and cerebellum (*explains on the nervous system diagram*),
- 15 L: No, it doesn’t go to the cerebellum (*glances at Kutay*),
- 16 Ay: Because it turns back from the spinal cord, and then he pulls his hand away here (*pointing at the diagram*).
- 17 K: Right (*looks at his partners*),
- 18 L: because the reflex doesn’t go to the brain or cerebellum.
- 19 K: In this case we think (*points at his brain*),

20 L: No, you don't think,

21 K: I mean, if it goes to brain, we think,

22 L: Yes. But this one doesn't go to the brain, Kutay.

23 K: Of course not (*shaking his head*),

24 Ay: He is just touching and pulling his hand away,

25 L: It [reflex] can be like playing a piano. If you always play the same song, you can play it without looking at the piano. But if you misplay even one musical note, your brain immediately starts thinking about it,

26 Ay: Then you try to correct it [*mistake*],

27 K: Alright,

28 Ay: Should we draw this? (*Pointing at the model*)

29 L + K: (*nodding*)

30 T: (*Approaches to the group A and starts listening to group discussion*)

31 K: So eventually we say, first of all the acid contacts the neurons (*glances at teacher and points at the nervous system diagram*),

32 L: It goes to the spinal cord (*looking at the diagram*),

33 K: and the neuron reaches to the spinal cord, the spinal cord decides on the response and sends it back,

34 T: Yes, wonderful, this is the most noticeable event in this activity.

35 L: The reflex is formed and he pulls his hand away,

36 Ay: Pulls immediately,

37 L: In other words, the signal doesn't go to the brain (*glances at teacher*),

38 T: Brilliant, well done! You can explain this event in this way. You don't have to draw it on the nervous system model (*she leaves the group*),

39 All: (*All start writing*)

40 L: The neurons in child's hand go to the spinal cord. The spinal cord, without asking the brain

41 Ay: What (*glances at L*)?

42 L: The spinal cord, without asking or consulting the brain, sends its response to the hand for defence purposes. And the child pulls his hand away as a reflex (*all writing*). Wow, this small piece of writing happens in less than one second, even less (*glances at her partners with an amazed facial expression*).

43 K: Well, it is the human body.

44 L: It is so amazing,

- 45 Ay: It happens like this (*pulling her arm quickly twice to show how fast the reflex happens*). Right, but sometimes if the stimulus isn't that strong, you just become aware of the pain and then you pull it later without forming a reflex.
- 46 L: Yeah, most likely...

Appendix G – An example dialogue from the introductory activities

Introductory activity 2

Turns	Transcriptions
4	T: Ok, listen, don't talk please. Now, I would like you to tell me what you know about this concept (<i>writing on the whiteboard</i>). Our concept is 'neuron cell'. What is neuron cell? This is our key concept. What does neuron cell mean? (<i>looking at the class</i>)
5	Brus: Can we look at the books?
6	T: Actually, I want you to tell us what you have in your mind at the moment. We are doing a kind of brainstorming. What do we know about the neuron cell?
7	B: Ok (<i>nodding</i>),
8	T: Only those of you have an idea? Ezel,
9	Ezel: Neuron cells are in nerves, so they constitute our nerves,
10	T: Ok, good. Ezel says that they are the cells found in our nerves. Akin,
11	Akin: As I know, it is the basic functional unit of the nervous system,
12	T: The basic functional unit. Else? Yes, I am listening to you (<i>Vural</i>)
13	V: Something passes through inside the neurons, and goes until the brain (<i>looks puzzled</i>)
14	T: So, the messages are conveyed by means of the neurons? (<i>Looking at Vural</i>)
15	V: Yes,
16	T: Alright. Ezgi,
17	E: Teacher, neuron conveys information to the brain when we touch something (<i>showing</i>). It conveys the information to the brain, um, passing through the nerves. The message also goes from brain to the target organ when we do something,
18	T: Ok, um, when thinking about the relationship between cell and tissue, how do you describe the systematic for neuron cells from bottom to top according to the cell-tissue systematic which you learnt last year? (<i>Standing and looking at whole class</i>)
19	S: For the nervous system?
20	T: (<i>Nodding</i>) starting from basic neuron cell to the top, from simple towards complex. Murat?
21	Murat (M): Teacher, I am not sure, but it must be neuron, nerves,

22 T: Nerves (*nodding and looking at Murat*)

23 M: Nervous tissues and skin (*expresses uncertainty*),

24 T: Ok, else?

25 M: That's it.

26 T: Ok, this is what Murat thinks (*rise in the volume of her voice*). Anyone who agrees with Murat or anyone who wants to explain it differently (*looks at whole class*)?

27 V: (*Raising his hand*)

28 T: Vural?

29 V: Teacher, mine is different. I would say, neuron cells, nerve tissues, brain,

30 T: Ok, brain (*nodding*),

31 V: and lastly nervous system and here we are (*smiles and shows his body*)

32 T: Yes, good! Neuron cells come together to constitute nerve tissue, nerve tissues come together to constitute organs, like brain (*points the diagram on the whiteboard*),

33 V: brain, spinal cord.

34 Melis: spinal bulb,

35 T: yes and when these organs come together, they constitute the nervous system,

Appendix H – An example dialogue from whole class discussions

Whole class discussion 5

Turns	Transcriptions
1	T: Alright, before answering these questions, I want you to tell me what you understand from these tables and graphs. Now kids, you can find information everywhere nowadays. If you Google any word, you can get a great deal of information in many forms. But the important thing is to evaluate and interpret the information you access. I haven't mentioned about hypothalamus and ADH before. I just gave you a little information and what I expected from you was to interpret the graphs and tables in relation to these concepts. Anyway now, what is this ADH hormone? And what is your understanding of these diagrams? We will speak group by group. Well, let's start with Basak's group. Basak, what do you understand from ADH hormone?
2	B: Teacher, what we understand is that – now, in these pictures – Um, ADH hormone balances the water level in the body,
3	T: Good, Brus?
4	B: For instance, here (1 st picture) it is in balance, but in this picture (2 nd), when the water level is high, ADH hormone is secreted less,
5	T: Yes,
6	B: In this picture (3 rd), when the water level is low, ADH is secreted more and so the water level is equalised,
7	T: balanced,
8	B: balanced,
9	T: Ok, what does your group think, Ezgi?
10	Ez: Teacher, We agree what Basak has just said. We also thought that it balances the water level, as well as the water level in the kidneys. Because, as shown here with arrows, in the first picture both water and ADH is ,
11	T: Yes (<i>nodding</i>)
12	Ez: And here, there is too much water in the picture below. So ADH is reduced in order to balance the water level. But, when there is enough water, it is reduced a little bit. And if the water level is so low, ADH is secreted more in order to balance it.
13	T: Brilliant, well done! So, what does ADH do there?

-
- 14 V: It adjusts the water level,
- 15 T: Water level, ok. Ezel? What is your interpretation?
- 16 E: Yes, teacher, we also made similar interpretations. When there is less water in the kidneys, a signal is sent to the brain. We think that the ADH hormone plays a role for balancing. We understand like this. It balances the water level in the body and the kidneys. So we have made this kind of interpretation. If there is less water in the kidneys, a signal is sent. Hypothalamus asks the pituitary gland and the pituitary gland secretes more hormones. But um, when it sends a signal as it is much, a signal again goes to the hypothalamus. Then it again asks the pituitary gland and the pituitary gland secretes fewer hormones.
- 17 T: Well. Zeynep,
- 18 Z: Teacher, we all also agree with what's been said so far. But as a group, we thought that when the water level is high, the kidneys may send some kind of strong signals to the brain,
- 18 T: You mean, depending on the water level?
- 19 Z: Yes. In a sense, it cannot directly tell the exact water level, but perhaps, it may tell the water level as being strong or weak. Then, as it is written in the notes, the hypothalamus has an influence on the pituitary gland as stopping or releasing. We thought that this signal could function in this way. So the brain sends the ADH hormone in a certain amount.
- 20 T: Well, ok. Akin, what does your group think?
- 21 Ak: Teacher, I will make a comment. Now, when the urinary bladder is empty, both of them are equalised.
- 22 T: Yes,
- 23 Ak: When the urinary bladder is full, the water level increases, and the ADH hormone is decreasing. When the urinary bladder is less full, the water level decreases, and the ADH hormone is secreted more.
- 24 T: Yes, secreted more. Ok, good! Leman (*smiles*)
- 25 L: Teacher, our group thought like this. ADH and the water level in the blood is inversely proportional. In other words, when the amount of water is high, ADH decreases. When the level of water in the blood is less, ADH become more. Now, as Akin says, when balanced, there is no urine. ADH in the blood becomes less, when less, the water level becomes high. So depending on this, more urine is produced. But when there is more ADH in the blood, the amount of water becomes less as well as the less urine produced.
-
-

52 T: Now, kids, we excrete the excess water through urinary route. And when we
do this, we also dispose of urea and some of the minerals. So, given that, how
does the hypothalamus understand whether the water level is high or low, in
your opinion? Basak,

53 Bas: Well, we think like that. When there is less or more water in the kidneys, a
message is sent from here to the brain.

54 T: Basak is saying that a message is sent to the brain. Yes, Akin

55 Ak: Can a nervous signal be sent from the kidneys?

56 T: Well, good question. So, let's think about how the hypothalamus is informed
that there is more water in the body? How does the hypothalamus receive this
message? In the body, the signal can only be sent via hormones or nerves. How
does this message go? Through nerves from the kidneys as Akin suggested?
Murat,

57 M: Teacher, I think, it can be like this [What Ak says]. Like, the less water in
the kidneys can be perceived and then ADH is secreted,

58 T: Now, one question, what is most associated with the water in your body?

59 S: Blood?

60 T: It is related to the blood, isn't it?

61 En: Because, the blood has a concentration,

62 T: Yes, brilliant En, well done! Can you tell us again (*smiles*)?

63 En: I think, there must be a concentration in the blood,

64 T: ok, how is it concentrated?

65 En: Teacher, when there is more water, it is pretty liquid. But when water is
taken out a little bit, the blood begins to solidify, but not exactly becoming
solid,

66 T: Yes, good, more concentrated,

67 En: Sure, so the blood flows a little bit more slowly,

68 T: And, you are saying that the hypothalamus realises this?

69 En: Yes (*nodding*),

70 T: Zeynep,

71 Ze: Teacher, if Engin hasn't told us this, I wouldn't be able to make any word.
But his idea is really helpful to me. Now, if the blood doesn't go to the cells,
none of the cell can survive. Since hypothalamus is composed of cells, naturally
the blood also goes to the hypothalamus. In this way, it can understand the
blood concentration.

72 T: Good, Vural,

73 V: Teacher, you don't really see me as I am sitting very close to you,
74 T: So then, let me stay away from you (*joking and being humorous*)
75 V: I think that I can add something what Engin's said,
76 T: It seems that Engin has opened up all of the class's horizon,
77 V: Yeah,
78 Ak: Engin (*smiles*)
79 V: Engin told that the blood is clotting,
80 T: No, he didn't say that the blood was clotting. He said the blood was
becoming more?
81 V: Yes, sorry, more concentrated. The blood is filtered through the kidneys,
82 T: Listen to Vural,
83 V: So ADH is enabling the water to remain in the blood.
84 T: Yes, good explanation. Now, normally the density of pure water is 1
kg/cubic meter,
85 All: Yes,
86 T: In your previous class, you learnt the density and acidity. Didn't you?
87 All: Yes, we've learnt,
