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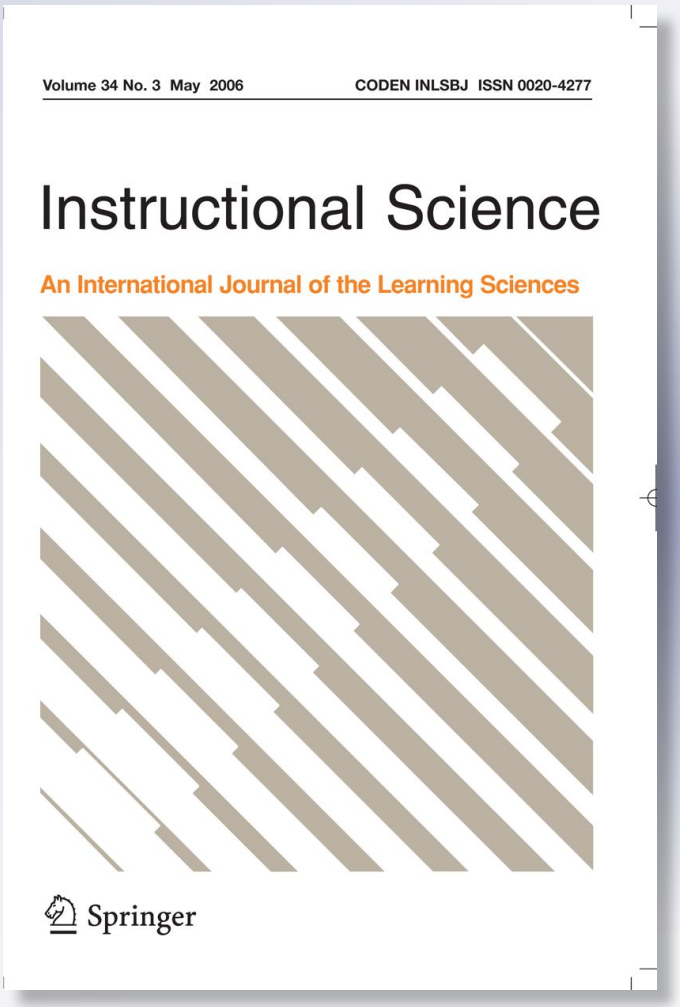

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Effective self- and co-regulation in collaborative learning groups: An analysis of how students regulate problem solving of authentic interdisciplinary tasks

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Abstract This study examined the use of collaborative interdisciplinary authentic tasks as a context in which learners develop and use self-regulated learning (SRL) processes. Participants included sixty-four students from a U.S. middle school whose residents are largely from low-income families. Students worked in groups to design and carry out an authentic, interdisciplinary project over a 9-week period. A Hierarchical Linear Modeling (HLM) analysis suggested that students' individual SRL increased over the course of the project and that co-regulated learning (CRL) moderated this relationship. Furthermore, one group was selected as an exemplar case to provide an explanation of how co-regulation occurred and influenced SRL in this collaborative group. Theoretical and practical implications of the research are discussed.

Keywords Authentic tasks · Self-regulated learning · Middle school · Strategy-use · Co-regulation

Self-regulated learning (SRL) refers to the metacognitive, motivational, and behavioral processes individuals use to direct and control their learning (Winne and Perry 2000; Zimmerman 1990). Metacognitive processes include setting goals and monitoring and controlling progress toward goals. Motivational processes refer to efforts to engage in and persist at tasks by participating in activities that may include maintaining high self-efficacy through positive self-talk, adopting a mastery-goal orientation, or expressing intrinsic task interest. Behavioral strategies include techniques used to sustain attention as well as choosing and structuring learning environments so that they are conducive for learning.[1] Students gain significant benefits in terms of higher levels of performance on tasks and achievement outcomes when they are able to self-regulate effectively (Wolters and Pintrich

[1] This study focused on self-regulation of cognition and did not examine the motivational or behavioral regulation processes that are included in extended conceptualizations of SRL (e.g., Pintrich 2000; Zimmerman 2000).

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1998; Zimmerman and Bandura 1994; Zimmerman 2002). Despite these benefits, researchers continue to find that students do not possess the self-regulatory skills demanded by colleges, employers, and trade schools to succeed (Winne and Jamison-Noel 2003). This has prompted reform efforts in national and state standards that call for instruction aimed at developing students' SRL (EU Council 2002; NCTM 2000).

A number of explicit instructional intervention programs for developing students' SRL (e.g., strategic training programs and tutoring programs) have shown to be effective (e.g., Butler et al. 2001; Graham et al. 1992; Zimmerman and Kitsantas 1997, 1999). Unfortunately, most teachers do not have the time or training to implement explicit, strategic instructional programs (United States Department of Education 2008; Zimmerman et al. 1996). As an alternative to SRL intervention programs, researchers have explored how to structure tasks to help students develop SRL within content-oriented instruction. For example, complex, meaningful tasks in which students had multiple opportunities for decision making, autonomy, self- and peer evaluation, and worked collaboratively (referred to herein as "high-SRL tasks") were especially effective at increasing students' SRL skills (Boekaerts and Cascallar 2006; Perry 1998; Perry et al. 2006). Although researchers have primarily focused on measuring students' SRL on high-SRL tasks, because these tasks involve forms of collaborative learning there may also be potential to investigate instances of co-regulation. Co-regulation describes interactions between two or more peers that coordinate SRL processes (McCaslin and Hickey 2001; Yowell and Smylie 1999) and can vary from *other* regulation to *shared* regulation (Vauras et al. 2003). Providing opportunities for students to co-regulate learning may be particularly effective during instruction if it has the potential to enhance students' self-regulation.

The information-rich climate of our world has made it increasingly important for individuals to be self-regulating. Schools and classrooms have the potential to foster the development of students' SRL using explicit and implicit pedagogies. For a number of years, researchers (e.g., Corno and Mandinach 2004; Järvelä and Järvenoja 2007; Järvelä and Järvenoja, in press; McCaslin and Hickey 2001; Vauras et al. 2003) have theorized about how interaction among peers in collaborative environments might provide a context in which to foster the development of SRL. However, empirical evidence to substantiate this claim has been relatively absent from the literature. To address this gap, this study examined how co-regulation moderated changes in students' SRL during a high-SRL task. Specifically, sixteen groups' reported SRL and co-regulated learning responses were analyzed using Hierarchical Linear Modeling (HLM) to determine whether students' SRL increased over the course of the project, and the role, if any, co-regulation had in the process. Furthermore, one group was selected as an exemplar case to provide a rich understanding and explanation of how co-regulation occurred and influenced SRL in this collaborative group. This study extends self-regulated learning literature by offering an alternative to instructional interventions, and furthers primarily qualitative research studies that have focused on co-regulation processes alone (e.g., Hurme and Järvelä 2005; Järvelä and Järvenoja, in press; Vauras et al. 2003). With regard to practice, state and national standards have long advocated the use of collaborative learning contexts in U. S. K-12 classrooms (AAAS 1993; NCTM 2000). As such, using collaborative learning environments to develop SRL lessens the need to implement new instructional methods, which may require substantial time, effort, and resources, when students can potentially benefit from existing best-practice pedagogy.

Metacognition in self-regulated learning

The research on SRL is exhaustive and beyond the scope of this paper; however, a review of the metacognitive processes that affect SRL are highlighted as they were the focus of investigation in this study (e.g., Boekaerts and Cascallar 2006; Schwartz and Metcalfe 1994, for full reviews).

Theoretical conceptualization of metacognition

Flavell (1979) originally defined metacognition as "thinking about thinking." In more recent conceptualizations of metacognition, researchers distinguish among metacognitive knowledge (MK), metacognitive monitoring (MM), and metacognitive control (MC) (Dunlosky and Metcalfe 2009). Generally, researchers have found some evidence for a relationship among MK, MM, and MC in problem solving (Swanson 1990), reading comprehension (Schraw 1994), and strategy-use (Pintrich and DeGroot 1990). MK refers to knowledge about cognition in general and can include knowledge of how learning occurs and how to improve learning processes (Dunlosky and Metcalfe 2009). Typically, MK increases with age (Baker 1989) and achievement level (Schneider and Pressley 1989).

Assessing or evaluating the status of a specific cognitive process (e.g., problem solving) is referred to as MM. Nelson and Narens (1994) has noted several examples of MM including ease of learning, judgments of learning, and feelings of knowing that refer to predictions about (1) task difficulty before learning takes place, (2) future performance during or immediately following learning, or (3) the ability to recall items that were initially difficult to remember during learning, respectively. Research suggests that monitoring ability develops slowly and is quite poor in children and even adults (Pressley and Ghatala 1990), and lower for poor performing as opposed to high performing students (Hacker et al. 2000). Fortunately, there is some evidence that MM can improve. For example, Shraw et al. (1993) found that students in an educational psychology course who were offered an incentive (e.g., extra credit) for either performing well on a test or making highly accurate judgments about their performance, had better calibrated predictions compared to students who were not given an incentive. Moreover, Nietfeld et al. (2006) noted that students who received explicit training in MM processes were more likely than students with no training to make more accurate judgments about their performance, and that accurate judgments predicted higher scores on the end-of-course exam.

MC refers to efforts to regulate a particular facet of a cognitive activity. This includes planning, monitoring, and evaluation strategies (Veenman et al. 2006). Planning includes selecting appropriate strategies and allocating resources accordingly to organize and prepare for an upcoming task. Research examining skilled writers found that older students were more likely to plan, and when they planned they engaged in global rather than local planning. This research also noted that better writers spent more time planning and setting goals prior to carrying out the task and they were better able to achieve their plans compared with poorer writers (Bereiter and Scardamalia 1987). Self-monitoring consists of strategies individuals employ as they compare their performance with their standards or learning goals.[2]

Researchers have noted a positive relationship between effective self-monitoring strategies, overall strategic knowledge, and performance (Isaacson and Fujita 2006).

[2] Although theoretically distinct, it may be difficult to operationalize MM from self-monitoring control strategies since activities associated with both concepts are quite similar (Pintrich 2000).

Self-evaluation includes strategies individuals use to assess learning processes and outcomes and can lead to decisions to continue, modify, or cease their actions. There is some evidence that the ability to self-evaluate is positively associated with increased performance. Research by Ramdass and Zimmerman (2008), for example, found that middle school students' performance increased when given an opportunity to evaluate their learning after completing a mathematics task. In general, self-evaluations were more likely to contribute to learning when they were frequent, combined with mastery goals, and conveyed information that students may not have attained independently (Schunk 1996).

Nelson and Narens (1994) have proposed a theoretical model for the relationship between metacognition and cognition. The framework is composed of two levels: an object-level (i.e., a particular cognitive process such as problem solving) and a meta-level (i.e., a model of the object-level that may be influenced by an individual's MK). Communication between the levels occurs via MM and MC processes. MM includes continued efforts to assess the state of object-level activities so the meta-level model can be updated to reflect circumstances at the object-level. Alternatively, MC processes are used when information at the meta-level results in changes to activities occurring at the object-level. The results from several research studies suggest a positive association between MM and MC processes. For example, Luwel et al. (2003) interviewed 6th graders and found that MM positively predicted students' use of MC strategies. The authors suggested that high-quality MM helped students make better decisions about which strategies were best suited to regulate particular aspects of the task. Sperling et al. (2004) documented similar results in their research with first year college students noting MM helped students make better decisions as to how to tailor particular strategies to specific task requirements. For example, one student began reading a passage using a particular strategy (e.g., self-questioning), but selected and applied a different strategy (e.g., outlining) after monitoring led to the realization that the first strategy was not appropriate for that aspect of the task.

Co-regulated learning

Co-regulation describes interactions between two or more peers that coordinate SRL processes (McCaslin and Hickey 2001; Yowell and Smylie 1999) and can vary from *other* regulation to *shared* regulation (Vauras et al. 2003). If a more regulated peer (MRP) assumes responsibility for regulating a less regulated peer (LRP), co-regulation is *other* regulated. A goal of this type of CRL is for the LRP to move toward autonomous SRL by working with a MRP who has a repertoire of SRL strategies and skill implementing these strategies under varied conditions. Theoretically, working with a MRP creates opportunities for a LRP to learn strategies from a MRP that he/she may be able to use in the future. Thus, for students in need of additional regulatory support, working with MRPs can create opportunities for LRPs to increase their knowledge of and skill implementing regulatory strategies. Alternatively, when two or more group members jointly assume regulation activities, co-regulation is *shared*. Instead of a MRP whose regulatory strategies are superior to those of a LRP, responsibility for regulating the task is shared equally among the group members. In these cases, there are a number of academic and social benefits to all group members as a result of participating in co-regulatory processes (Vauras et al. 2003).

Co-regulated learning is derived from Vygotsky's (1962) concept of internalization. Vygotsky suggested that thought manifests itself within socially mediated activities, and the purpose of inquiry is to examine how the learner internalizes processes learned in social

activities (Palincsar and Herrenkohl 1999). By interacting with more knowledgeable others (MKO), individuals are exposed to a number of social tools (e.g., cultural objects, language, and social institutions) and expert behavior that they then can internalize (Vygotsky 1962). Furthermore, working with a MKO on joint activities provides opportunities for the expert to support the learner as he/she acquires knowledge or skills. These processes suggest that knowledge or skill development is not transferred to learners, but rather, learners are guided and participate in the process (Rogoff 1990). Finally, the theory posits that the learner will use strategies or knowledge internalized from the social activity to manage future tasks.

An examination of several examples from the literature can help to illustrate the different forms of co-regulation. For example, Patrick and Middleton (2002) described an instance during a global warming unit in which a MRP co-regulated a LRP and how this led to the LRP's own efforts to self-regulate. During this unit, students worked in groups to explore issues related to colors and heat absorption. At one point, a group member posed a question to the group and each member offered an hypothesis to explain the phenomena. During group member A's explanation, group member B questioned an underlying assumption in A's argument. This prompt led group member A to evaluate his reasoning, recognize his misconception, and eventually withdraw his hypothesis from the discussion. Over the remainder of the project, group member A gradually began to self-regulate (e.g., monitor and evaluate) independently by exercising judgments of his performance. Similarly, Hadwin et al. (2005) examined 10 graduate students' SRL as they constructed course portfolios with the assistance of a teacher mentor over the course of an academic term. Analysis of teacher–student discourse over several collaborative sessions found a decrease in episodes of teacher-regulation (i.e., other regulation) and an increase in instances of self-regulation. Types of teacher-regulated activities included modeling, offering explanations, descriptions, or instruction, and providing feedback related to strategy use. Evidence of student-regulation occurred when "social influences [shifted] to self-influences" and students assumed responsibility for self-regulating these processes autonomously (p. 418).

Shared regulation is when multiple group members jointly assume responsibility for regulation activities and is conceptually similar to co-construction of knowledge. For example, Vauras et al. (2003) examined high-ability fourth-grade students' shared regulation as they worked collaboratively on mathematical problems in a computer-supported gaming environment. Investigating both individual and social processes, the researchers found that effective shared regulation led to high-quality learning, use of deep-level strategies, and transfer. Furthermore, the authors noted that the type and quality of shared regulation observed related to the nature of the task at hand. Similarly, research by Järvelä et al. (2008) found that groups of college-aged students employed a number of shared regulation strategies (e.g., social reinforcement, task structuring) to sustain motivation during a collaborative educational psychology task and that this helped them control task-specific social challenges. Finally, research by Kempler and Linnenbrink-Garcia (2007) investigated shared regulation among sixth grade students working collaboratively on a mathematics unit and found that although both groups frequently employed strategies to regulate each other's cognition and behavior, the quality of these processes were predominately low-level. Low-level strategies were those that did not serve to deepen understanding such as a brief reminder to re-engage in the task or efforts to take over a fellow group member's task responsibilities without providing explanations or feedback. This pattern was also found in research by Hurme and Järvelä (2005) and Volet et al. (2009a). Therefore, although these studies highlight the potential co-regulation may have

for learning and performance outcomes, high quality co-regulation is not simply guaranteed as a result of students working in groups.

The context for SRL: high-SRL tasks

Recall that complex, meaningful tasks in which students had multiple opportunities for decision making, autonomy, self- and peer evaluation, and worked collaboratively ("high-SRL tasks") were especially effective at increasing students' SRL skills (Boekaerts and Cascallar 2006; Perry et al. 2006). Because high-SRL tasks involve collaboration, they may be particularly effective contexts to measure and promote co-regulation as well. Perry and colleagues have researched extensively on the task features that promote high-level SRL in early elementary school classrooms (see Perry et al. 2002, for a review). For example, complex, personally meaningful tasks promoted SRL because they required students to coordinate multiple cognitive, motivational, and behavioral processes to construct various products. Embedded in such tasks were various opportunities for students to exercise choice. For example, when Perry et al. (2002) observed kindergarten and first grade literacy tasks, they found that lessons were structured to offer students different alternatives in what and how they learned (e.g., choice in what to read and write about and selecting various comprehension strategies for decoding). When students were afforded choice, it created opportunities for them to practice and refine SRL skills, therefore helping to support the development of such skills over time. Related to choice, high-SRL tasks were also designed to control challenge. This is because when tasks were overly challenging, students became frustrated and as a result employed defensive practices such as non-persistence and task avoidance, therefore serving to thwart any opportunities for SRL development (Turner 1997). To address this issue, task demands were differentiated to meet each student's current skill level. For example, on one task struggling students were allowed to draw their new ending to the *Three Little Pigs* before having to provide a print description. Allowing students the opportunity to pictorially represent their ideas before they constructed a narrative provided them with just enough support to successfully regulate the task independently. High-SRL tasks also included multiple opportunities for self- and peer evaluations. Self- and peer evaluations of their own and other classmates' work were important because students were asked to reflect on their own learning, the task demands, and potential strategies to improve their own and each other's work. Examples included developing and using rubrics to evaluate their own and each other's research projects and self- and peer editing of their personal reflections of their writing processes. Frequent use of self- and peer evaluations created a classroom culture based on personal progress by treating evaluations as opportunities for students to learn from their mistakes and share strategies for successful learning.

Finally, high-SRL tasks frequently included opportunities for students to work collaboratively (see Dillenbourg 1999, for a review of the distinction between collaborative and cooperative learning). Underlying effective collaboration is the notion of interdependence (Cohen 1994). For example, Cohen (1994) found that when collaborative tasks were structured to emphasize interdependent reciprocal relationships, students learned that the success of the group relied on individuals assuming responsibility for sharing their regulatory processes and helping each other develop these skills. One method used for promoting interdependency is to provide students with only one worksheet or require them to turn in one collaborative group product (Johnson and Johnson 1990; Kempler and Linnenbrink-Garcia 2007). This technique elicited interdependence by encouraging

students to form common goals (i.e., positive goal interdependence), and share resources to attain those goals (i.e., resource interdependence) (Johnson and Johnson 1990). Research by Johnson et al. (1990) found that groups who were resource and goal interdependent functioned more effectively (e.g., greater interaction, increased high-level processing) compared to groups who were only resource interdependent (e.g., jigsaw groups) or goal interdependent (e.g., traditional cooperative learning groups). Finally, Huber and Eppler (1990) found that collaborative learning groups that were solely resource interdependent were the most ineffective groups because there was little motivation for higher functioning students to ensure that lower ability students learned effective SRL processes.

Research questions and hypotheses

This study examined how co-regulation moderated changes in students' SRL during a high-SRL task. Specifically, the research included two hypotheses and explored one qualitative research question. The hypotheses are that (1) students' SRL would increase over the course of the 9-week project because the task was designed to support the development of SRL; and (2) that students' CRL scores would moderate the change in individuals' SRL, because collaborative tasks were designed to promote interdependence. To gain a rich understanding and explanation of how co-regulation occurs and influences SRL, a case study analysis was conducted to examine the actions of students engaged in these activities. The focus of the qualitative analysis was: How does one group's co-regulated learning processes lead to increases in students' independent SRL?

Method

Participants

Participants included 64 middle school students (age range, 12–14) from a large urban gifted and talented (G&T) school in the northeastern United States. Students applied to the G&T program during first grade based on their academic, artistic, performing arts, *or* athletic abilities. Therefore, all students were not academically gifted. The racial and ethnic composition of the school reflected the larger diversity of the district in that 64% of students were Hispanic, 25% of students were African American, 10% of students were Caucasian, and 2% were Asian. 77% of students were eligible for a free or reduced price lunch program, which was consistent with the district average. The state average, however, was 27%.

The task

Students worked collaboratively to design and carry out an interdisciplinary project that included the features of high-SRL tasks described earlier. Students were afforded many opportunities to make choices that included selecting a topic and planning how to solve it. This required students to routinely engage in decision-making processes in order to regulate their use of time and resources effectively. Tasks were designed to be meaningful by allowing students to explore topics that were of interest to them and that were authentic (see Brown et al. 1989). Finally, there were multiple opportunities for students to engage in

self- and peer evaluations of their plans, processes, and products. Thus, this project was student-centered in that students had complete authority for decision making on all aspects of the project and students were responsible for the success or failure of their project. Although the nature of the task allowed for a variety of projects, all projects included these underlying high-SRL task features.

For example, one group interested in learning about dinosaurs researched various dinosaurs in the late Jurassic period in order to design a new wing for the Museum of Natural History. To gain a real-world perspective, the group contacted the Director of Education for the Museum of Natural History, who provided them with information on the process researchers, scientists, and interior designers use to construct a new wing. Students used diagrams from the museum's website as well as information about the size of NYC blocks to calculate the dimensions of their wing. Next, after a discussion regarding the most efficient and logical layout designs, students agreed to group dinosaurs by geographic region. Last, students used ratios to make a scaled model of their new wing, along with educational activities to help visitors learn more about Jurassic era dinosaurs. This project reflected the types of projects students designed as part of this task (See Table 5 in Appendix for additional project descriptions).

The context

The school administration was interested in implementing student-centered pedagogies and designated a class period to implement this task within the daily schedule. Band practice was also held during this class period and so those students were not eligible to be part of the sample. To be equitable to students, the school requested that all students who were not part of the school band be included in the research design, so a control group was not feasible. Students ($N = 64$) were randomly assigned to one of four classrooms. Within each classroom, students were assigned to groups of four based on their interests in mathematics, language arts, science, performing arts, or writing in order to ensure they would be able to agree on a common project topic. These groupings were based on an interest questionnaire the school distributed at the end of the previous school year. Each class met for 45 min a day, 5 days a week for 9 weeks.

To encourage students to exercise autonomy in designing and implementing their projects, teachers deferred decision making, problem solving, and conflict resolution to students. Ultimately, the intent was to investigate the strategies students employed when they relied on each other to manage and control group processes. Teachers were present in an advisory capacity, meaning they were not trained or expected to facilitate group interactions.

Procedure

During week one, students completed the *SRL Questionnaire* and were assigned to groups. All students participated in a series of daily team building exercises to build cohesion and interdependence among group members before they began to design their projects (see Cohen 1994, for a description). During week two, students constructed a group collaborative collage. The purpose of this exercise was to help students identify their shared interests and this led to the identification of one or two themes that group members agreed that they would like to base their projects. Also during week two, each group received a group binder. In each binder were a number of supporting materials to structure the development of students' group projects. The materials were intended to (1) ensure that

group members could describe their projects in narrative form, (2) help students identify their learning goals for their project, and (3) serve as a record of their long term plans. Also included in their binders were a number of materials to help group members manage their projects such as daily, weekly, and monthly calendars. Students completed the *CRL Questionnaire* during week six and the *SRL Questionnaire* once again during the final week of the project (i.e., week nine).

Measures

Self-regulated learning questionnaire

This 13-item measure (Table 1) assessed the degree to which students set goals, and monitored and controlled progress toward goals. Items from this survey were adapted from SRL scales in the literature (Martinez-Pons 1999; Wolters et al. 2005) and were chosen because of their pervasiveness, internal reliability scores, and prior use with middle school populations. Because of the initial diversity of the survey items, the statements were rewritten to refer to a common activity (i.e., writing a research report). This activity was chosen because it required the same types of skills students used in this project. On the SRL time 3 survey, the items referred to working on this project. Students responded to statements based on a four-point scale where the number indicated the degree to which the student believed he or she did what the item described. Choices included always (4), most of the time (3), some of the time (2), or never (1). Cronbach's alpha on this scale was .80.

Co-regulated learning questionnaire

This questionnaire contained 19 items (Table 1) and was intended to measure the same constructs as the *SRL Questionnaire* but related to students' co-regulatory processes. Since there was no existing CRL survey available, a similar procedure Goddard (2002) used to change a self-efficacy scale to a collective efficacy scale by replacing "I" as the object of the efficacy items to "We" was used here. For example, statements such as, "Before we started working on our project, I set goals to guide what steps I will take" was restated as

Table 1 Example survey items

Examples of Items from the Self-Regulated Learning Questionnaire
1. Each day I read our plans carefully before I began working on our project
2. I made sure I understood before we moved on to the next part of our project
3. I double-checked my work to make sure I was doing it right
4. I paid attention to and knew the purpose of what I was working on
5. I made sure the number of plans our group set for the day was manageable
Examples of Items from the Co-Regulated Learning Questionnaire
1. In our group we looked over each other's work to see if we understood what each member was doing
2. At the end of each day, we left enough time to plan for the next day
3. We double-checked each other's work to make sure we were all doing it right
4. When we planned, we talked about if our plans were realistic
5. I knew what my other group members were working on during our project

"Before we started working on our project, our group set goals to guide what steps we would take." Cronbach's alpha for this scale was .83.

Hierarchical linear modeling (HLM) analysis

A power analysis for this particular sample size based on Optimal Design Version 1.76 (Spybrook et al. 2008) suggested that there was adequate power to detect a large effect size with this number of groups and group size. HLM (Bryk et al. 1996) was the statistical procedure for this study because of the data's nested structure. HLM is particularly suited for nested data because it allows for the examination of group-level effects on individual outcomes without inflating type 1 error (Snijders and Bosker 1999). The software program HLM6 (Raudenbush et al. 2004) was used to carry out the HLM analysis, and the final solution was estimated using restricted maximum likelihood (Raudenbush and Bryk 2002; Raudenbush et al. 2004). The HLM analysis allowed for modeling individual-level and group-level variables simultaneously. In this study the individual-level outcome variable was the change in SRL over the course of the project (referred to as SRL). This was measured by subtracting post-test SRL scores from pre-test SRL scores (McArdle and Nesselroade 1994). The level-2 variable was the group co-regulated learning score (referred to as CRL) and this served as the predictor variable in the analysis.

Case study analysis

Although the current study is part of a larger qualitative investigation that examined self- and co-regulatory processes in all 16 groups, space limitations here do not allow for investigation of the findings to be presented. Instead, using purposeful sampling one group was selected for analysis in this investigation (Patton 2002). Purposeful sampling is the process of selecting "people or groups on the basis of their potential manifestation or representation of important theoretical constructs" (Patton 2002, p. 238) and has been used by other researchers studying SRL (e.g., Perry et al. 2002). The purpose of this case study is to provide an exemplar description of how co-regulated efforts led to increased self-regulation within one collaborative group in order to better understand these processes.

The group chosen was composed of two-sixth grade males and two-sixth grade females in which three of the members were Hispanic and the fourth member was African American. They all shared an interest in soccer and decided that they would form a district wide all-star soccer team for their group project. To do so, they determined a systematic method of collecting and analyzing individual players' statistics from multiple teams across the district in order to recruit the players for their team. Recorded in an excel spreadsheet they tracked potential players' names, experience (measured in years), as well as summary statistics from the prior season (e.g., goals scored, number of yellow and red cards). This information was used to select twenty-two members for their all-star team. After they learned that professional players sign contracts when they join a team, the group members researched examples of sports contracts and used these to create their own contract for their team members. As part of their project, they also designed a team logo and uniform and contacted potential vendors for pricing details. Designing the uniforms was not just about style; the group members also researched different lightweight, sweat, and heat-resistant fabrics as well. Finally, the group members researched various types and prices of equipment (e.g., cleats, gloves, shin guards, and so on) and constructed a budget—of their expenses.

Data analysis procedure

The video transcripts ($N = 11$) of students' group work served as the data for the qualitative analysis. In total, there were more than 1,544 min of video footage analyzed for this particular group. The process began by constructing summaries of the group members' conversations and behavior for every 15 min of tape, defined as an episode. Discourse within an episode that reflected on-task behavior (i.e., talk indicating that the group member is focused on the group project) was transcribed verbatim with descriptions of students' nonverbal behavior. All of the data were coded with Nvivo software program for qualitative research in order to organize, cross-reference, and synthesize the data. Initially a coding scheme by Wolters et al. (2005) adapted to include co-regulation processes was used to code the data. However, during analysis it was modified to reflect new codes and ways to categorize the data (see Table 2). Thus, coding reflected inductive and deductive processes (Thomas 2006). Lastly, another researcher coded 20% of the transcripts in order to establish reliability, which was 88%. After discussion, agreement was reached on all codes.

At this point frequency counts of codes were calculated. Because the context of students' regulation (i.e., the time period) helped to understand differences in regulatory processes, the 9-week total project period was divided into three time periods. Each time period (that is, Time 1, Time 2, and Time 3) referred to the first, second, and third 3-week period of the project, respectively. This was used to investigate if different regulatory processes were more pronounced at different times within the project. Next, instances of SRL and CRL (by time-period) were compiled into two separate documents and narratives

Table 2 Coding scheme

Regulatory area	Codes	Example from data
Planning	*Product Planning*	
	Product planning involved defining the scope of the project and identifying its goals	Mark suggests that the all-star team should be comprised of students from their own district as opposed to professional players
	Process Planning	
	Assigned group roles or decided the order in which they would complete tasks relating to a project idea	Henry assigns Gabrielle the task of researching players' statistics
Monitoring	*Task Monitoring*	
	Monitored the status of the tasks they created through process planning	Gabrielle self-regulates by stating, "What am I supposed to be doing? Uh, Uh…Research players' stats."
	Content Monitoring	
	Monitored their own and each other's ideas, research, and/or problem solving related to the content of their projects	Sandy engages in self-talk while gathering research: "Ok, I already put sizes, and I already put colors. What else is there?"
Evaluation	*Content Evaluation*	
	Statements aimed to assess or judge content related to their project	Henry evaluates Mark's research on contracts
	Mechanics Evaluation	
	Assessing and correcting formatting, spelling, grammar, or punctuation errors	Henry corrects Mark's spelling error

were constructed to describe themes across the codes and to make connections across themes and data sources. When identifying themes it was important to search for negative instances of potential patterns or alternative explanations that could help interpret the data. Finally, a cross-narrative analysis was performed to describe similarities, differences, and connections across self- and co-regulation and time.

Results

HLM results

Means and standard deviations for responses to the SRL and CRL scales are presented in Table 3. Results of the unconditional model showed that the amount of variation in SRL between groups was significant ($\gamma_{00} = 3.04$, $t(15) = 41.42$, $p < .05$). More importantly, this data was used to compute the intra-class correlation for the outcome variable, SRL. In this analysis, 18% of the variance in SRL was within groups, and 4% was between groups resulting in an intra-class correlation of .18. Lastly, because the group level variance was significant, $X^2(15) = 31.02$, $p < .05$, it was appropriate to move forward with a multilevel analysis (Raudenbush and Bryk 2002) because there was variance at the group level that could still account for differences in SRL.

The conditioned model was used to address research question one, Do students' SRL change over a 9-week high-SRL task?; and research question two, Do co-regulated learning processes moderate the change in individual group member's SRL? The predictor variable was grand mean centered by subtracting the grand mean for CRL from all values of that variable (Kreft and De Leeuw 1998). Table 4 displays the results for this model. With regard to research question one, the intercept, γ_{00} was significant $\gamma_{00} = .31$, $t(14) = 4.88$, $p < .05$, which indicated that the change in SRL was significantly different from zero. Given that this intercept was positive, this analysis supported hypothesis one that students' SRL increased over the course of the project. Similarly, the average co-regulated learning score, γ_{02}, was positive and significant, which supported research question two that groups with higher co-regulated learning scores were also more likely to have individuals whose SRL increased over the course of the project. This supported hypothesis two, that co-regulated learning scores moderated the change in individual SRL. Lastly, because the group-level variance was not significant, $X^2(14) = 11.79$, $p > .05$, it was not appropriate to move forward with a multilevel analysis (Raudenbush and Bryk 2002) because there was not variance at the group level that could still account for differences in SRL.

Case study results

To address research question 3, a case study analysis of one group's regulatory processes is presented as an exemplar model of how co-regulated efforts by group members can lead to increases in SRL. Planning activities included strategies group members employed to

Table 3 Means and standard deviations

	Mean	St. deviation
Self-regulated learning (Time 1)	2.73	.43
Self-regulated learning (Time 3)	3.04	.47
Co-regulated learning (Time 2)	3.13	.31

Table 4 Summary statistics for the conditioned model

Fixed effects	Coefficient	Standard error	*T*-ratio	*df*	*p* value
For intercept, β_0					
Intercept, γ_{00}	.31	.06	4.88	14	.00*
Average CRL, γ_{01}	.60	.27	2.21	14	.04*

	Standard deviation	Variance	Approximate *df*	Chi-square	*p* value
Intercept1, U_o	.01	.00	14	11.79	>.5
Level 1, R	.51	.26			

* $p < .05$

define, organize, and prepare their projects. Because of the open-ended nature of this task, students planned both the scope and goals of their projects (i.e., product planning) as well as the steps they would take to carry out their projects (e.g., assign group members tasks, decide the order of tasks; i.e., process planning). The highest number of instances of product planning occurred during Time 1 and Henry assumed responsibility for the majority of these activities. For example, Henry contributed three of the four project ideas and he was the only person who accepted proposed project ideas. There were three instances where Mark contributed to product planning by elaborating on project ideas. For example, Mark added that the all-star team should be comprised of students from their own district as opposed to professional players. However, Gabrielle and Sandy only summarized project ideas that were proposed by Henry.

By assuming responsibility for suggesting and accepting project ideas, Henry co-regulated product planning for the other members of his group. These co-regulated activities determined the direction and goals of the project. His co-regulated efforts were well received by the other group members. That is, all members were involved and interested in implementing Henry's project idea and appeared from the video to welcome Henry's efforts at organizing the direction of their project. This was evident from the group members' reactions to Henry's ideas which included head nods, sitting straight and leaning forward, and expressions such as "Ooo," "Yes," and/or "Ahh cool."

Similar to product planning, the majority of process planning activities occurred during Time 1 and were co-regulated by Henry. For example, Gabrielle had just finished researching the information on different types of soccer balls and Henry noticed this and assigned Gabrielle the task of researching players' statistics.

Henry	Gabrielle: What are you going to do? (*Henry leans over and looks at her paper.)*
Gabrielle	Henry: (*Gabrielle* reads from the paper on her desk) Umm
Henry	Gabrielle (*Henry looks over a paper on his desk.*) Research…on…
Henry	Gabrielle: Do research on players' stats
Gabrielle	Gabrielle: Re…search…play…ers'…stats. (*Gabrielle writes this information down on a research page)*

In this example, Henry assigned Gabrielle a task to carry out for the rest of the period. This example was representative of the type of co-regulation that occurred in this group in that Henry consistently assumed responsibility for co-regulating the other group members' process planning. In this role, Henry's behavior might be categorized as authoritarian since he regularly assigned tasks to his fellow group members. However, Henry's efforts at co-

regulating were often accompanied by explanations for why it was necessary to complete a particular assignment. For example, in the excerpt noted above, Henry responded to Gabrielle's acceptance of the task by stating, "Yeah because we like…we like need players' stats so we can…like so we can choose our people for the team. Get it?" Furthermore, an examination of the other group members' reactions to Henry also provided support that they accepted his regulatory role. For example, after Henry assigned Gabrielle the task of researching players' statistics from the previous season, she worked on this task for the rest of the period. Since Gabrielle did not resist Henry's directives, it seems likely that she accepted his authority and did not resent it. Thus, co-regulated planning activities in the soccer group were primarily other-regulated by Henry and he assumed regulatory control over both product and process planning. Furthermore, the majority of planning activities occurred early in Time 1 presumably because project ideas were proposed by Henry early on and accepted with little modifications from the other group members. This allowed for process planning (how the project would be carried out) to occur toward the beginning of the project.

Monitoring processes resulted from group members comparing their performance to their goals, and then generating feedback that could be used to guide further action. For example, group members' task monitored the status of the tasks they/others created through process planning. The majority of task monitoring was observed during Time 1. Recall, this group had a general understanding of their project idea early on in Time 1. This allowed them to engage in process planning which in turn provided them with tasks to monitor. An example of co-regulated task monitoring occurred when each group member decided that they would take a research page to fill out and Henry decided that Sandy would research information related to the uniforms. Two days after these tasks were established, Henry monitored Sandy, "Sandy, hey Sandy, did you finish your research… Sandy did you finish [looking up in binder] the designing uniforms research yet?" (*Sandy nods*) "Ok because we need that information because some materials are better than others, like you don't sweat that much in them, and we need to know what materials so we can look up the costs." Henry monitored Sandy's progress in an effort to ensure that group members were completing their assigned tasks.

Although Henry co-regulated the majority of planning activities, responsibility for self- and co-regulated forms of monitoring rotated more equally among group members. For example, Gabrielle self-regulated task monitoring by stating, "What am I supposed to be doing? Uh, Uh (*Gabrielle thought for a second*). Research players' stats. Henry, can you give me another research page thingie' for players' stats?" Here Gabrielle monitored her progress on an assigned task originally assigned to her by Henry, thereby keeping herself on track with the group's process planning. What possibly contributed to the increased instances of self- and co-regulated task monitoring? Recall that Henry established well-defined project ideas and engaged in process planning which led to the assignment of tasks to group members during Time 1. These co-regulated efforts may have scaffolded the other group members' regulation in that Henry defined the scope of the task and assigned them group roles. Once this initial framework for the project was defined, it may have reduced the complexity of the task enough for all group members to begin contributing to self- and co-regulated task monitoring processes. An alternative explanation for this shift toward increased self- and co-regulated monitoring is that because the majority of planning occurred early during Time 1 when group cohesion may have been low, as students began to feel more comfortable working with each other they were more likely to assume responsibility for regulatory processes.

Task monitoring (both individual and co-regulated) played an important role in how this group regulated their project. For the person doing the monitoring, he or she benefited from

being able to practice monitoring processes which led to the refinement of these processes over time. Moreover, when a group member monitored himself or herself, it served to keep the group member on-task and because all group members monitored fellow group members at various points throughout the project, they all practiced refining their monitoring skills. Alternatively, for the individual who was being monitored, it served to refocus attention back on-task and maintain on-task behavior (refer to the example above when Henry monitored Sandy). The group as a whole also benefited from its members checking that everyone was doing what they were assigned. By ensuring that everyone fulfilled the tasks assigned to them, it increased the likelihood that all parts of the project were completed, and provided an opportunity for group members to revise their process planning if a particular group member did not fulfill his assigned role. For example, Sandy was assigned the task of researching what material soccer balls were made of. The next day Gabrielle asked Sandy if she had finished looking up this information. When Gabrielle learned that Sandy had not completed her task, she told this to Henry, who assigned Gabrielle the duty of researching soccer balls. Thus, Gabrielle's monitoring of Sandy led to process planning changes.

Group members also monitored their own and each other's ideas, research, and/or problem solving related to the content of their projects (referred to as content monitoring). Content monitoring accounted for almost 75% of the total instances of monitoring, and all group members engaged in a number of instances of self- and co-regulated content monitoring. An example of self-regulated content monitoring occurred when Sandy worked on gathering research related to designing uniforms and she engaged in self-talk, "Ok, I already put sizes, and I already put colors. What else is there?" Self-monitoring served as a way for her to self-check her research related to the task, and make sure that she did not duplicate previous work. There were also instances of co-regulated content monitoring. For example, Sandy made a chart to brainstorm everything the group would need to research (or make a decision on) in order to make a soccer team. This included deciding on a name, designing the uniforms, and researching contracts. Gabrielle sat next to Sandy and glanced at her paper. She noticed that Sandy had written "permits" twice, and said, "You already wrote down permits." This type of co-regulated monitoring benefited Sandy in that Gabrielle helped her to identify a mistake in her work. In other words, when group members were all involved in monitoring each other's work it allowed for the identification of inconsistencies, misinterpretations, or gaps in the research, which when addressed could lead to a better quality product.

Evaluations were appraisals, corrections, or assessments students made about their own performance or that of other group members. Two types of evaluative activities were noted in the soccer group. The first type of evaluations included statements aimed to assess or judge content related to their project (referred to as content evaluation). Content was not only written work and included the assessment and correction of verbal statements related to the content of the project. In the soccer group, all six instances of content evaluation were made by Henry and were co-regulated. Co-regulated content evaluation statements were other-regulated and referred to instances when Henry assessed and corrected content information presented by another group member. In one instance, Henry examined the research on contracts Mark had completed. Mark had researched contracts on Wikipedia and had written down its definition. Henry stated, "We need to find examples of different contracts, not just the definition of it. Like you gotta' like find some examples of sports contracts so we can use them to make ours." By evaluating Mark's research page, Henry identified insufficient information in Mark's work. This feedback led Mark to revise his research on contracts in order to find an example of a sports contract that the group could

use as a model. This evaluation may result in Mark learning new strategies that were not part of his original repertoire. Henry also evaluated the other group members' work for formatting, spelling, grammar, or punctuation errors (referred to as evaluating mechanics). For example, while researching information related to contracts, Mark attempted to spell the word "negotiate" several times. Finally, Henry stated, "Just write it and I will correct it [the spelling] later." Because Henry corrected Mark's misspelling for him, Mark may not have benefited from Henry's co-regulation. Although the quality of the end product had improved because Henry corrected the spelling, Mark did not learn how to spell it himself. Thus, the quality of co-regulation and the accuracy of the statement appear important in order for the learner to benefit from co-regulation. Here the quality of Henry's co-regulated statement is low but the statement was accurate. Had Henry's statement been inaccurate this could have hindered the quality of the project.

Discussion

This study examined the relationship between students' self- and co-regulation processes during a high-SRL task. Based on a review of the literature on SRL, CRL, and features of high-SRL tasks, several hypotheses regarding the relationship between SRL and CRL were proposed. The results of the HLM analysis indicated that students' SRL scores increased over the course of the project and that CRL scores moderated this relationship. When group members co-regulated it may have supported their acquisition and refinement of SRL skills and contributed to the increase in their SRL over the project period. This finding is consistent with and extends Vygotsky's (1962) concept of internalization in that students internalized processes learned in social activities (Palincsar and Herrenkohl 1999), and these processes became part of their individual repertoire of regulatory skills. More specifically, this research offers empirical support of McCaslin and Hickey's (2001) theoretical description of the relationship between self- and co-regulated learning processes. Although other researchers have investigated co-regulation in group settings, their focus has been on co-regulated processes alone and not on the interaction between self- and co-regulation. For example, Vauras et al. (2003), and Järvelä et al. (2008) have documented a number of shared regulation strategies that benefit learning and transfer, but have not investigated the effect (if any) on students' self-regulation. When researchers have considered the interactions between self- and co-regulated learning the focus has been on qualitative descriptions (e.g., Hadwin et al. 2005). Further research investigating this relationship across grade levels and within various domains will be needed to substantiate these findings.

Complex, meaningful tasks in which students had multiple opportunities for decision making, autonomy, self- and peer evaluation, and worked collaboratively ("high-SRL tasks") were especially effective at increasing students' SRL skills. Results from the quantitative analysis suggest that high-SRL tasks may also be particularly effective contexts to measure and promote co-regulation as well. Such student-centered pedagogies create multiple opportunities for group members to serve as MRPs to one another. In doing so, expertise can be shared among students and there is the potential for group members to assume a collective responsibility for helping each other develop regulatory skills. By increasing interactions among students, there is the potential for students to learn new strategies or modify existing strategies as they work collaboratively with their peers on joint tasks. Furthermore, opportunities to use rubrics to evaluate their own and each other's performance may also promote self- and co-regulated processes. When students engage

self- and peer evaluations it has the potential to create a classroom culture based on personal progress. Students learn to treat evaluations as opportunities to deepen understanding and share/refine regulatory strategies. While further research is needed to discern whether there are qualitative differences in the type(s) of task-related features that promote CRL, this finding suggests benefits to designing tasks to include these features.

Although the majority of research and theory on other-regulation focuses on the benefits to the LRP, the quantitative findings provide initial support that MRPs may benefit from CRL processes as well. While the current sample was insufficient to assess differences in outcomes for LRPs and MRPs separately, the analyses indicated that all students reported higher levels of SRL at Time 3. That is, co-regulation may have benefits for both the person doing the regulating and other group members to whom the action is directed, and this may lead to increases or refinements in both students' SRL. For MRPs, co-regulation may help them to recognize, refine, and modify inconsistencies in their own regulatory strategy-use, which they can use to advance they own SRL. Similar results have been noted in the peer tutoring research. Consistent with the old adage: "to teach is to learn twice," research on peer tutoring has found increases in both the tutee's and tutor's academic and social development as a result of peer tutoring interventions (Benard 1990; Cohen et al. 1982; Swengel 1991). Further investigation, focused on the MRP, is needed in order to substantiate these claims and gain a complete understanding of the co-regulation process and outcomes.

Video of students' interactions was analyzed in order to present an exemplar case study of how one group's use of co-regulated learning processes potentially led to increases in individual members' SRL. First, the results of the case study analysis successfully replicated findings from previous work that have documented the role of the other-regulator in collaborative tasks. Consistent with this work, the current study described instances of other-regulation in which a particular group member assumed responsibility for regulating another group member's learning on a joint task. Whereas in previously reported research, the role of the other-regulated was assumed by one group member exclusively, this study extends those findings by documenting instances in which the role of other-regulator rotated among group members depending on whose regulatory processes was better suited for that task.

Second, there were several qualities about the nature of co-regulated interactions that potentially contributed to individual group members' increased use of self- and co-regulated processes over the course of the project. First, given the highly complex, semi-structured nature of this task, one of the most important and potentially difficult aspects of this project was establishing group goals and a shared plan. Recall that Henry created a well-defined project idea and engaged in process planning which led to the assignment of tasks to group members. Once this initial framework for the project was defined, it may have reduced task complexity enough for all group members to begin contributing to self- and co-regulated monitoring processes. In essence, Henry may have established what Cohen (1994) termed interdependence, by encouraging group members to adopt common goals and to all actively contribute to attaining those goals. It is unclear whether this group would have functioned effectively without a clear plan of direction and the means to achieve those goals without Henry's co-regulated efforts. Furthermore, when Henry co-regulated learning, his statements were accompanied by explanations. Henry used explanations to describe and justify the use of various regulatory processes to other group members in order to manage the task. For example, when Henry engaged in co-regulated planning processes he explained his reasoning behind his proposed product/process plans, and why it was necessary to engage in or modify specific aspects of the plan. When Henry co-regulated evaluation processes he not only identified the error in someone else's work, but explained why it was incorrect and strategies the individual could use to improve.

Providing explanations has been identified as one characteristic of effective co-regulation (Volet et al. 2009a, b) and may have potentially facilitated other group members' use of co-regulated processes in this group by making the rationale and benefits for these employed regulatory strategies overt. That is, by listening to the explanation, particularly aspects related to strategy choice, group members were exposed to the co-regulator's internal thinking processes which provided justifications and contextual cues for why a particular strategy was appropriate or useful to employ. This information about various regulatory processes would be needed if group members were to attempt to apply those regulatory strategies independently in the future. Thus, providing explanations may have the same benefit for co-regulated learning as it does for problem-solving processes (Cobb et al. 1992; Webb et al. 2006) and high-level engagement (Visschers-Pliejers et al. 2006) during group work. Further research will be needed to substantiate this claim.

As group members began to assume greater responsibility for regulatory activities it became important for a MRP to fade co-regulated support. In this group, Henry was an authoritative leader (Goldman 2007) in that he relinquished control over co-regulated processes as individual group members became more comfortable assuming these responsibilities. It is not clear the effect on social cohesion, the quality of the project, or the development of SRL had Henry refused to share responsibility for CRL processes with his other group members. In fact, Vauras et al. (2003) has noted that negotiation, an important element of effective collaboration, can be constrained if group roles do not allow space for it. The fact that Henry was able to share co-regulated processes with his other group members may have played a role in motivating them to take on greater responsibility for regulating themselves and others. In thinking about how the current study could be used to improve students' SRL, instruction and/or interventions to ensure that the MRP fade co-regulatory support needs to be investigated further.

The underlying theoretical assumption of other-regulation is that there is a linear relationship between co- and self-regulated learning processes. Although the findings suggest preliminary support for this relationship, in this group effective co-regulation led to increases in co-regulated processes by other group members as well. Thus, it may be that within the group context co-regulation not only leads to increases in students' SRL but co-regulatory processes as well. Furthermore, CRL did not lead to increases in self-regulated processes in all types of SRL processes. That is, there were few instances where other group members besides Henry assumed responsibility for planning or evaluation processes. Volet et al. (2009b) have argued that within each SRL area there are differences in the quality of students' regulatory processes. For example, student A may use mostly high-level planning strategies while student B's planning strategies may be considered low-level. The current study extends these findings by suggesting that there may be qualitative differences among types of regulatory processes as well. For example in this study, group members were more likely to engage in self- and co-regulated monitoring processes (both high and low) as opposed to planning and evaluation strategies. Although low group cohesion may explain group members' low involvement in self-and co-regulated planning processes at the start of the project, because evaluation processes occurred most frequently at the end of the project, this explanation would not be sufficient to justify low self- and co-regulated evaluation processes as well. In general, the literature on self-regulated evaluation processes has suggested that students find these types of processes difficult to enact (Abram et al. 2002). Perhaps after repeated interactions within this group, co-regulated processes would have led to increases in self- and co-regulated planning and evaluation processes as well. Studies in which the task extends over a longer project period or in which group members work on multiple tasks may be needed to investigate this claim.

Limitations

Thus, the current study provides initial support for how self- and co-regulated learning processes occur within a collaborative context. While studying these interactions within schools has implications for ecological validity, there were undoubtedly constraints placed on the methodological procedures as a result of conducting classroom-based research. First, the sample size was limited and there was no opportunity to have a control group because the school required that all students not involved in the school band be participants in the study. Furthermore, political pressures within the district prevented measurement of teacher-level effects that presumably influenced the quality of students work. Although teachers were instructed to encourage groups to work independently and this appeared from the video transcripts to be true, the extent to which teacher interactions affected group performance could not be investigated directly. Third, the use of self-report measures always carries concerns regarding the validity of the measure and participants' understanding of the items. In this study the SRL questionnaire employed is established in the field as a valid and reliable measure. The CRL questionnaire is a modified version of the SRL and was used for the first time in this study. Thus, the quantitative results need to be accepted with caution regarding the nature of students' response to this measure. Fourth, whereas interview data would have allowed inferences to be drawn about *why* students used a particular regulation strategy, there was insufficient time in students' schedules to allow interviews to take place. Absent these data, it was difficult to understand the purpose of proposed strategies and the effect a strategy had on the person being regulated.

While the case study analysis provided a rich description of self- and co-regulated processes in this collaborative group, because it was a purposefully selected exemplar group the findings cannot be directly generalized to the larger population being studied. However, these findings do translate to the theory under investigation and illustrate how co-regulation occurred in one group of middle school students. Examinations of exemplar groups provide researchers with real-life descriptions of how research- based strategies are enacted by learners.

Conclusion

Despite these limitations, the data extends theory by suggesting that co-regulated processes in a group context may lead to increases in self- and co-regulatory learning processes, and noting the conditions under which it is likely to occur. In terms of significance to practice, because collaborative learning is an instructional method teachers already use, or are at least familiar with, this approach capitalizes on existing classroom practices. This lessens the need to implement new instructional methods, which may require substantial time, effort, and resources when students may benefit from an existing method. Finally, this study addresses recent reform efforts in national and state standards that call for developing regulatory strategy-use and employing collaborative learning methods (AAAS 1993; NCTM 2000).

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Appendix

See Table 5.

Table 5 Description of group projects

Research related to their project	Products related to their project
1. Automatic ball launcher for baseball	Designed an automatic ball dispenser for soccer out of Legos
2. Late Jurassic period dinosaurs	Designed a new wing for the museum of Natural History
3. Endangered species	Created a model of a Koala's habitat with safeguards included, became active members of a local save the animals organization
4. Robots	Created a modeled diagram of the parts of a robot and how it functions, built a robot
5. Advertising	Organized advertising materials for school play, solicited business for support, constructed program and supporting materials for school play
6. Videogame design	Used a tutorial to design their own videogame
7. How to start an all-star soccer team, elements of a soccer franchise	Started an all-star soccer team for the school: made contracts, designed uniforms and logo, purchased equipment

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