

Cooperative Learning and Co-Regulation: Exploring Students' Teamwork Strategies in Higher Education

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Abstract—This research paper investigates the effectiveness of cooperative learning and co-regulation strategies in promoting teamwork and enhancing students' performance in higher education. The study was conducted in an in-person intermediate-level information system design course with 152 students divided into 31 teams. The students utilized the Scrum framework to manage a semester-long project with three milestones. Retrospective data were collected at the end of each milestone, and the first milestone data were analyzed in this study. Through a thematic analysis of retrospective data collected after the first milestone, the study examines students' planning, monitoring, and reflection strategies. The findings reveal that students demonstrated adaptive planning, equitable contribution, and task allocation based on individual strengths and preferences. In terms of monitoring, students adopted a proactive approach, displayed relational competence, and utilized both synchronous and asynchronous communication channels. Regarding reflection, students valued effective planning and execution but struggled with time management. They developed concrete improvement strategies for the next milestone, emphasizing realistic deadlines, improved communication, and a better understanding of team members' strengths. This research contributes to the understanding of cooperative learning and co-regulation in promoting effective teamwork in higher education. The findings have implications for pedagogical practices and suggest the importance of integrating cooperative learning and co-regulation strategies in team-based learning environments. Future research can further explore the application of these strategies in different educational contexts and investigate their long-term effects on students' performance and engagement.

Keywords— *higher education, co-regulated learning, cooperative learning, Scrum, teamwork*

I. INTRODUCTION

In engineering educational spaces, it is fundamental to provide effective learning environments for students to thrive academically and emotionally. Traditional institutions focus their teaching pedagogies on individualistic learning where students are encouraged to solve exams, assignments, and tasks independently. However, research has proven that cooperative learning has superior effects on students learning [1] and emotional intelligence [2]. Working cooperatively not only

impacts students' learning but also helps reduce the gap between engineering studies and industry application; in the 21st century, one of the most required skills in industry is teamwork [3,4].

Cooperative learning is an educational approach that helps learners to work in small groups while promoting interpersonal and group skills, positive interdependence, accountability at both the individual and group levels, face-to-face promotive interaction, and group processing. Within this cooperative framework, students engage in academic tasks and construct knowledge collectively.

Co-regulation is a framework that encourages students to develop self-regulatory skills through the social and cultural context of individuals with a shared objective. Co-regulated learning concerns interdependence, collaboration, and mutual support between team members. Co-regulation also emphasizes the cultivation of metacognitive awareness, planning or forethought, performance, and self-reflection, encouraging students to take ownership of their learning.

This article aims to investigate the students' strategies for effective teamwork in higher education engineering. To this end, we use cooperative learning and co-regulation as the lenses and guidelines for the study.

II. BACKGROUND

A. Teamwork in Higher Education

As we entered the new century, employers adopted a managerial structure that promotes teamwork due to advancements in workplace technology that facilitate group work. Additionally, formal training programs for teamwork have become a common practice in organizations, including higher education, where it is essential to teach effective team behaviors and performance. The values of teamwork efficacy and potency are instilled in learners at an early age and are continually tested and practiced through various situational and group work assignments [5]. Studies on teamwork training have explored various formats, such as didactic classroom-style education, interactive workshops, and simulation training. Although all formats showed improvement, the effectiveness varied depending on the type of training. While interactive workshops and simulation training resulted in significant

improvements, didactic classroom-style training did not show the same results. This highlights the importance of interactive and collaborative education for successful teamwork. While there has been research on the effects of teamwork training and pedagogy, studies on intercultural competence in teamwork have mainly focused on virtual teams. Therefore, more research is necessary to better understand the role of culture in teamwork.

B. Teamwork Pedagogy

The concept of teamwork refers to multiple individuals working together towards a shared goal while remaining accountable for their individual contributions. To promote effective teamwork, pedagogical practices aim to improve students' communication skills through increased dynamic interactions within teams while working on projects [4]. Rather than focusing solely on the end product or results, teamwork pedagogy prioritizes the psychological and communicative capabilities of students, such as collaborative problem-solving and accountability. This approach can be combined with other teaching methods, such as cooperative learning and problem-based learning, as examined in this study.

C. Cooperative Learning through Scrum

Cooperative learning usually involves two, three, or four students who have a specific task towards a common goal. Cooperative learning has five principles (a) interpersonal and group skills such as leadership, communication, and conflict resolution [6,7]; (b) positive interdependence, where the group depends on each member to achieve the common goals [8]; (c) accountability at the individual and group levels, in which each member has a specific role and responsibility that holds them accountable within the group [9]; (d) face to face promotive interaction, where frequent and meaningful communication is needed among group members [10]; and (e) group processing, where members of the group reflect on their experience and find room for improvement [11].

Cooperative learning is a pedagogical framework that emphasizes learning and performing in small groups, generally by allowing students a form of guided independence to explore concepts on their own within these groups under the supervision of an instructor. It was found to have a positive correlation in association with students' academic performances, in addition to a positive effect on students' interpersonal skills such as self-esteem, cooperative work skills, etc. [12]. As such, cooperative learning was found as an effective pedagogy in the STEM field, which placed high emphasis on students' learning through groups working towards a common goal, often in an academic capstone setting. As this is the case, cooperative learning is an ideal implementation method for Scrum frameworks in information technology and small group settings striving to achieve a common projected goal.

Cooperative learning operates on five core principles: positive interdependence, training of interpersonal skills, promotive internal interactions, individual accountability, and group processing [13]. Positive interdependence is the understanding that an individual's efforts within a group are

contributing factors to the team's overall success. Interpersonal skills are an individual's social skills, both previously developed and refined throughout project execution, which assist in the team's effective completion of the project (e.g., conflict handling skills, verbal and non-verbal communication skills, etc.). Promotive internal interactions are the constant positive communications between group members that promote one another's success; these can be in the form of praise, feedback, and/or offers of assistance. Individual accountability is each group member's individual contribution to project work and facilitation of the work of other group members through feedback behaviors. Group processing is the strategy that a group has set forth to facilitate project execution. Furthermore, these procedures should be constantly analyzed and refined based on group member feedback regarding effectiveness and success.

A recent study explored the use of cooperative learning as a teaching mechanism for students in a worldwide pandemic situation, which required them to have fewer in-person interactions and perform through remote work [7]. This study was in the context of a systems design class where students were put into teams and given a case study for which they were to design an information system solution. For this study, there were two groups of students from two different semesters, one semester where they were taught in a typical classroom setting and one where they were taught entirely remotely. This design allowed for a one-to-one comparison of students' performances throughout the semester. It was found that while the remote students were able to perform similarly academically and collaboratively to the in-person counterparts from the previous semester, due to the nature of team cohesion, remote teams were less likely to apply interpersonal relationship-building strategies and procedures.

Another study published in 2018, in a similar context as the previous one, analyzed the implementation of Scrum in a cooperative learning environment through two approaches, overlapped and delayed [14]. The classroom setting had adopted Scrum concepts such as creating product backlogs, sprints and milestone deadlines, and project work at a small group level. The overlapped approach was to have sprints (prototyping deliverables) due amongst the milestones (design components), whereas the delayed approach had most of the design components due upfront and then had the prototyping deliverables come later. It was found that while both approaches had comparable progression and communication, the delayed approach was more conducive to students' learning about teamwork skills and better conveyed the purposes of the material taught in the course.

D. Project-Based Learning

Project-based learning (PBL) is a constructivist student-centered teaching method that guides students to learn by actively engaging in real problems; it usually involves students working in teams. Studies have shown that PBL helps students improve their problem-solving and critical-thinking skills [15], scientific skills, and learning outcomes [16], increases productivity and innovation skills [17], and improves students' technical and human skills [18].

III. THEORETICAL FRAMEWORK

This study was guided by the co-regulated learning framework [18]. To better understand co-regulated learning, self-regulated learning must be explained.

A. Self-Regulated Learning (SRL)

According to Hadwin and Oshige, self-regulation "is the process of becoming a strategic learner by actively monitoring and regulating metacognitive, motivational, and behavioral aspects of one's own learning [19]". Zimmerman [20] argues that self-regulated learning has three phases: (a) forethought, where individuals plan strategies and goals, using previous knowledge to prepare for the task; (b) performance, where individuals implement and regulate strategies according to feedback; and (c) self-reflection, where individuals reflect on their performance, outcomes, and make plans for improvement. Students who use SRL strategies improve academic performance [21,22].

B. Co-Regulated Learning

Co-regulated learning is a transitional process of SRL guided by the social and cultural context of individuals with a common goal [18]. Different from SRL, co-regulated learning involves interdependent collaboration and mutual support between individuals. Co-regulated learning has been proven to improve engagement in online environments [23], improve conceptual understandings and problem-solving skills [24], and engage in higher-order thinking and metacognitive processes [25]. Fig.1. demonstrates various phases of co-regulation. In this study, students were encouraged to plan, monitor their performance, and reflect on their performance and outcomes to make plans for improvement.

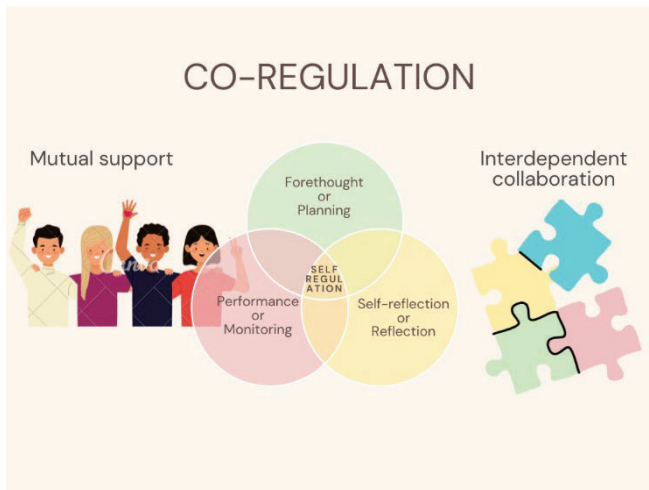


Fig. 1. Phases of Co-regulation

The co-regulation framework fits into our study. The essence of co-regulation is group self-regulation, which encompasses three components: forethought, performance, and self-reflection. Our study uses three equivalent components: planning, monitoring, and reflection. Students' retrospectives

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were studied by asking them about each of the later components. The two additional components of co-regulation: mutual support and interdependent collaboration— are encouraged through the cooperative learning approach.

IV. RESEARCH QUESTION

The overall research question of this study is: *How do cooperative learning and co-regulation strategies influence teamwork in higher education?*

Sub-Question 1 (Planning): How do team members engage in collaborative planning processes during team-based projects?

Sub-Question 2 (Monitoring): What mechanisms do team members utilize to monitor and assess progress during team-based projects?

Sub-Question 3 (Reflection): How do team members engage in reflective processes at the conclusion of team-based projects?

V. METHODS

A. Context, Participants, and Course Design

The context of the study was an in-person, three-credit hour, intermediate-level, information system design undergraduate course focused on teaching students about teamwork and generating models for developing effective information system solutions using the Unified Modeling Language (UML) and object-oriented tools.

A total of 152 students, divided into 31 teams of 4 to 5 members participated in the study. For team formation, students proposed preferred team members, either past collaborators or friends, during the first week of class. Subsequently, the course teaching assistant formed groups of 4 to 5 students based on their indicated preference. In cases where no preference was indicated by students, random selection was employed to form the groups. The objective was to accommodate students' preferences to the greatest extent possible during this process.

According to institutional data, the course demographics consisted of 123 (81%) male students and 29 (19%) female students. The ethnic background of the students participating in the study is shown in Table 1. Of those, 24% of the students in the course identified as international students, while the other 76% consisted of domestic students from the United States. The percentage ratio of international to domestic students in the course is representative of the international-to-domestic student ratio at the university level. Most of the students in the course were in the second year of their college education and were either pursuing a general computer and information technology or a cybersecurity degree.

Table 1. Demographic Details of Participants

Race	# of Students Identified	Percentage Ratio to the Overall Class Size
White	55	36.18%
Asian	46	30.26%
Hispanic/Latino	9	5.92%
Black/African American	7	4.60%
2+ races	35	23.03%

The teams worked on a semester-long system analysis and development project by first gathering system requirements, analyzing, designing, and implementing the system, and then presenting their product in the form of a demonstration. The course followed a weekly format with a 1.5-hour lecture every Tuesday and Thursday. The teaching approach involved active learning and team collaboration. During the Tuesday session, new concepts were introduced, practiced within teams, and followed by feedback. The Thursday session focused on project details and allowed students to work in teams on their projects.

The course integrated Scrum, a widely accepted and followed methodology in the technology industry where the software is delivered in increments [26]. Scrum combines technical, communication, and teamwork skills to support development teams in delivering quality software products [27]. Students were introduced to roles (development team, product owner, Scrum master), artifacts (product and sprint backlogs, product increment), and events (sprint planning, sprint increments, retrospectives). Students rotated roles throughout the course and engaged in continuous process improvement. Project milestones were managed through weekly sprint increments, and team reflections were conducted after major deliveries.

B. Data Collection

This study took place during a 16-week semester wherein the students worked in teams and participated in a semester-long system analysis and design project. The project was divided into three milestones, and at the end of each milestone, students were asked to submit a written retrospective about their experience throughout the milestone. This study uses retrospective data collected after the first milestone. Table 2 summarizes the questions students answered as part of their end-of-the-milestone guided retrospective.

Table 2. Retrospective Prompts for Data Collection

Phase	#	Retrospective Question
Planning	Q1	How did you plan the organization of work for the milestone? What were the team members' roles?
	Q2	How were activities assigned to each team member and what was the justification for that?
	Q3	How was the communication handled among team members?
Monitoring	Q4	What aspects of the team coordination/collaboration went well in this milestone?
	Q5	What aspects of the team coordination/collaboration went wrong in this milestone?
	Q6	What are possible concerns?
Reflection	Q7	What do you think as a team was particularly good about the milestone you just completed?
	Q8	What are areas or sections of the milestone that you just completed you think could be improved?
	Q9	What aspects do you think can be done better for the next milestone in terms of team performance?

C. Data Analysis

The data analysis method employed in this study involved a thematic analysis approach. Three coders systematically analyzed the retrospective data to identify patterns, themes, and meanings. The first step was to familiarize themselves with the data. Then, researchers generated initial codes by systematically identifying and labeling relevant segments like key concepts and ideas of the data (open coding). These initial codes formed the basis for the codebook, which provided a set of predefined codes to apply consistently across the dataset. Once the codebook was established, the researchers organized the codes into potential themes by identifying patterns and recurring topics through iterative refinement (axial coding). The themes that emerged after this step formed the basis of the study results. Researchers maintained a reflexive stance and engaged in peer debriefing to ensure rigor and validity.

D. Ethical and Trustworthiness Considerations

In this study, several measures were taken to uphold ethical standards and enhance the trustworthiness of the findings. The retrospective data used for analysis were anonymized, ensuring that individuals' identities and personal information remained confidential. Any potentially identifying details were removed to maintain anonymity.

To enhance the trustworthiness of the analysis, an interrater reliability (IRR) assessment was conducted, where three independent coders participated in the data analysis process. The IRR analysis measured the degree of agreement among the coders in applying the codes and identifying themes. The IRR score of 91% indicated a high level of agreement, demonstrating the consistency and reliability of the coding process.

To further ensure the trustworthiness of the analysis, a peer debriefing session was conducted where researchers discussed randomly selected retrospectives to align the understanding of the text and interpretation. Through peer debriefing, any potential biases or assumptions were critically examined and discussed, contributing to the rigor and validity of the analysis.

VI. RESULTS

The results discuss the research question: *How do cooperative learning and co-regulation strategies influence teamwork in higher education?* This section is organized into themes corresponding to each stage of co-regulated learning.

A. Planning

This section answers sub-question 1: How do team members engage in collaborative planning processes during team-based projects?

Students engaged in iterative and adaptive planning. The retrospective data reveals that students recognized the dynamic nature of the project and the need to adapt their plans as new information and insights emerged. Students demonstrated adaptability, flexibility, and responsiveness in their planning process, which allowed them to refine their plans, incorporate

new insights, and adapt to changing circumstances, ultimately leading to more effective and successful project outcomes.

Students aimed for equitable contribution. The retrospective data highlights students' commitment to equitable contribution through a systematic approach. Students recognized the importance of distributing tasks and responsibilities evenly, considering factors such as complexity, time requirements, and individual capacity, and engaged in transparent discussions, regular check-ins, and proactive adjustments to ensure that workload distribution remained fair and balanced throughout the project.

Students allocated tasks based on individual strengths and preferences. Data reveals that students took a thoughtful and strategic approach when assigning tasks to team members. They considered not only the requirements and complexity of each task but also the specific strengths and preferences of their peers. By matching individuals with tasks that aligned with their expertise and interests, students aimed to create a collaborative and harmonious work environment as well as optimize productivity and enhance team performance.

B. Monitoring

This section relates to sub-question 2: What mechanisms do team members utilize to monitor and assess progress during team-based projects?

Students adopted a proactive approach to monitoring progress. The data indicates that students were actively engaged in tracking their milestones, assessing their advancement, and making necessary adjustments, rather than passively waiting for feedback or relying solely on instructor guidance. Students employed various strategies, setting specific milestones and timelines, regularly reviewing their work against these targets, and actively seeking feedback from team members and instructors. Students demonstrated a keen awareness of the importance of staying on track and ensuring their work aligned with project objectives.

Students displayed relational competence. The retrospective data indicates that students recognized the importance of and displayed relational competence during the project. Firstly, students acknowledged the significance of understanding their team members on a personal level. They recognized that by engaging in personal communication and getting to know each other's strengths, weaknesses, and working styles, they were able to establish stronger connections and foster a collaborative environment. Secondly, students actively sought and valued feedback from their team members as well as offered help to others whenever needed. Furthermore, students placed importance on building and maintaining personal connections within the team. They expressed their appreciation for the positive team dynamics and the trust that was established among team members.

Students employed both synchronous and asynchronous communication for collaboration and coordination. The retrospective data indicate that most teams utilized a combination of various communication channels, such as in-person and virtual team meetings (synchronous) as well as instant messaging tools (asynchronous) to share project updates, discuss tasks, and address any issues or concerns.

Additionally, teams leveraged collaboration tools and software platforms like shared drives to enhance coordination and facilitate real-time collaboration. These tools provided a centralized space for team members to share documents, track changes, and engage in collaborative work, fostering efficient and effective communication.

C. Reflection

This section corresponds to sub-question 3: How do team members engage in reflective processes at the conclusion of team-based projects?

Students valued effective planning and execution for success. According to the retrospective data, teams expressed satisfaction with several aspects of the milestone they just completed. They highlighted effective goal setting as a strength, emphasizing the importance of clear objectives and milestones in guiding their work. Teams appreciated the breakdown of tasks and the allocation of responsibilities, as it facilitated individual and collective progress. Furthermore, teams acknowledged the significance of understanding project requirements, conducting research, and utilizing visual aids, which aided their planning and decision-making processes.

Students struggled with time management. One common concern raised in the retrospective data was the need for better time management. Many teams mentioned experiencing delays or starting tasks late, resulting in increased pressure and compromised quality. Additionally, teams expressed the desire for improved communication and collaboration. They recognized the importance of consistent and transparent communication but noted instances where communication breakdowns or misalignment occurred, leading to misunderstandings or inefficiencies.

Students developed concrete improvement strategies. Looking ahead to the next milestone, teams identified specific aspects they planned to improve to enhance their overall team performance. To address time management issues, teams planned to set realistic deadlines, regularly monitor progress against timelines, and address any delays proactively. Similarly, to enhance communication and collaboration, they planned to establish clear communication channels, improve active listening, and promote a culture of open dialogue and feedback. Additionally, teams recognized the importance of better understanding individual team members' strengths, preferences, and areas for growth to optimize task allocation and collaboration.

VII. DISCUSSION AND IMPLICATIONS

A. Discussion

This study was conducted in an in-person 16-week course where 152 students were encouraged to use the Scrum framework and cooperative learning to develop a project divided into three milestones. A survey was used to capture students' perceptions of the three learning phases of self-regulation and co-regulation (a) planning, (b) monitoring, and (c) reflection. These three learning phases were analyzed in the first milestone of the semester and suggested that students (a) engaged in iterative and adaptive planning, aimed for equitable

contribution, and allocated tasks based on individual strengths and preferences; (b) adopted a proactive approach to monitoring progress, displayed relational competence, employed both synchronous and asynchronous communication; and (c) valued effective planning and execution for success, struggled with the time management, and developed concrete improvement strategies.

The findings of this study indicate how cooperative learning promotes co-regulation. For example - Students demonstrated adaptive planning, which is an example of co-regulated learning, where students collaboratively plan strategies and goals and actively monitor and regulate metacognitive aspects of their own learning. Students also adopted a proactive approach to monitoring by actively tracking their performance, engaging in frequent and meaningful communication with team members, and utilizing both synchronous and asynchronous communication channels. This monitoring behavior reflects co-regulated learning, where students regulate their strategies according to feedback and engage in metacognitive processes to ensure effective teamwork. Finally, students engaged in reflective processes at the conclusion of team-based projects where they developed concrete improvement strategies for the next milestone, emphasizing realistic deadlines, improved communication, and a better understanding of team members' strengths. This reflection and development of improvement strategies align with the self-reflection component of co-regulated learning, where students reflect on their performance and outcomes, and make plans for improvement.

The findings of this study also highlight the effectiveness of cooperative learning and co-regulation strategies in promoting effective teamwork in higher education. The planning strategies employed by students showcased their ability to allocate tasks and roles based on individual strengths and preferences, fostering equitable contribution within the team. The monitoring strategies demonstrated proactive engagement and relational competence, facilitating effective coordination and communication. The reflection phase allowed students to identify areas for improvement and develop concrete strategies for enhancing team performance in future milestones.

B. Implications

Pedagogical Implications. The findings suggest that incorporating cooperative learning approaches, such as team-based projects and the use of frameworks like Scrum, can enhance students' ability to work collaboratively and achieve better outcomes. Educators can integrate these strategies into their courses to foster a collaborative learning environment and develop students' teamwork skills.

Technological Implications. The findings indicate that students utilized various communication tools and platforms, both synchronous and asynchronous, to monitor their progress, exchange ideas, and provide feedback to their teammates. This suggests that institutions should provide students with access to appropriate technological tools and resources that facilitate effective communication and collaboration.

Transferable Skills for the Workplace. The implications of this study extend beyond the educational context. The findings highlight the development of transferable skills that are highly valued in the professional world. The ability to collaborate, communicate effectively, adapt to changing circumstances, and allocate tasks based on individual strengths are all skills that can benefit individuals in their careers. Employers can take note of these findings and consider the significance of teamwork skills when evaluating job applicants and designing training programs.

VIII. CONCLUSION, LIMITATIONS, AND FUTURE WORK

The study had a few limitations. First, the research was conducted in the specific context of an intermediate-level information system design course, which may limit the generalizability of the findings to other disciplines or educational settings. Further research should explore the applicability of cooperative learning and co-regulation strategies in diverse academic fields to ascertain their effectiveness in promoting teamwork. The study had a relatively small sample size, which may further limit the generalizability of the findings. Including a larger and more diverse sample of students from different institutions and academic programs could enhance the external validity of the study.

Second, the data collected in this study relied solely on retrospective self-reporting by students. While the use of retrospective data provided valuable insights into students' experiences and perceptions, it is subject to recall bias and may not capture the full complexity of team dynamics and behaviors. Future research could incorporate additional data collection methods, such as direct observations or interviews, to complement and enrich the understanding of students' teamwork strategies.

Third, the study focused on a single milestone within the course, limiting the scope of analysis. Examining multiple milestones or the entire duration of the project could provide a more comprehensive understanding of how students' teamwork strategies evolve over time and their impact on overall project outcomes. This will be addressed in future works by the researchers.

The current research sheds light on the significance of cooperative learning and co-regulation strategies in promoting effective teamwork among students in higher education. The study findings reveal the importance of adaptive planning, equitable contribution, and task allocation based on individual strengths and preferences for enhancing team performance. Moreover, the study emphasizes the role of proactive monitoring, relational competence, and the use of synchronous and asynchronous communication in supporting effective teamwork. The implications of this research suggest the integration of cooperative learning approaches into pedagogical practices and the provision of appropriate technological resources to foster collaborative learning environments. By implementing these implications, educators can cultivate students' teamwork skills and prepare them for successful collaboration in future professional settings.

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