Exploring Self-Regulation and Shared Regulation in Collaborative Design Tasks

Julia Knot

BMS Psychology, University of Twente

Chandan Dasgupta

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Abstract

This research explores how self-regulation and shared regulation are shaped in a collaborative design task. With a focus on how group interactions, individual priorities and task iteration influence self-regulation and shared regulation. Thirteen university students performed an open-ended design task using Energy3D software. Using the AIRE, participants identified the biggest challenge for their group: *personal priorities, work and communication, teamwork, collaboration, external restraints.* Radar charts are used to score self-regulation and shared regulation. Teamwork is revealed to be the largest challenge for most groups. Results reveal an influence of teamwork dynamics, communication, and personal priorities on self-regulation. The findings contribute to theoretical understanding and can be used for designing collaborative learning environments in the future.

Keywords: self-regulation, shared regulation, collaborative design task, collaborative learning, teamwork, group dynamics, iterative task

Introduction

Background and Context

Collaborative learning plays an increasingly important role in today's educational landscape. It is recognized as an unmissable component for fostering teamwork and problem-solving skills (Järvelä & Hadwin, 2013). The ability to regulate one's learning process is an essential skill in the 21st century. However, research shows that learners consistently fail to plan and use learning strategies vital for collaborative learning and problem-solving (Järvelä and Hadwin, 2013). Most learners cannot regulate their process because it is complex and needs to be learned. Additionally, if regulation is complicated on an individual level, it becomes even more complicated when working in a group, known as socially shared regulation (Hadwin et al., 2011).

This research focuses on a specific intersection: How do self-regulation and shared regulation interact when working on an open-ended Computer-Aided Design tool-enabled design task in a small group? Self-regulation, the ability to control and guide one's thoughts, emotions, and behaviours, is fundamental to human psychology (Baumeister & Heatherton, 1996). Self-regulation encompasses social elements that influence individual self-regulation (Zimmerman, 2000).

In a collaborative task, individuals must work together to reach a common objective. Collaboration has many definitions; the most widely used describes collaboration as a process of shared understanding where participants, through interactions within a group, are committed to a shared goal and problem-solving (Roschelle & Teasley, 1995). Collaboration requires individuals to define their standards and aims to create a path to reach a shared goal by sharing responsibility for the end product (Roschelle & Teasley, 1995). To reach this goal, individuals need to be able to listen, negotiate, compromise, explain, and reconsider. A range of cooperative processes take place to create common ground within the group. In the processes, individuals aim to create the necessary and sufficient conditions to effectively and sufficiently complete the collaborative task. The group process, in turn, supports the individual's participation and regulation in the collaborative task (Crook, 2000).

Learning experiences authentic to the real world help develop knowledge that successfully transfers from the classroom to real life (Ströbel et al., 2013). Using design problems is a way to create an integrated environment similar to the real world. The design process allows students to participate in analysis, synthesis, and evaluation tasks while concentrating on producing solutions for real-world problems (Lawson, 2006). As they attempt to solve the design problem, these activities can give students a place to learn and apply their disciplinary knowledge. Computer Aided Design (CAD) software programs can be used to create an authentic design experience.

Research Problem and Rationale

Effective self-regulation and the ability to solve open-ended problems are integral components of psychological well-being, cognitive development, and adaptive functioning (Higgins, 2012). A better understanding of these constructs can inform therapeutic interventions, educational practices, and personal growth strategies (Baumeister et al., 2007).

Furthermore, while the field of psychology has made significant strides in investigating self-regulation and shared regulation in design tasks, a notable gap exists in comprehending their intertwined dynamics within collaborative learning settings, including CAD design tasks. (Martin, Sherin, & Osmundson, 2015). The complexity that collaborative tasks pose requires individual and shared regulation. This research aims to explore the influence of self-regulation and socially shared regulation when working on an open-ended design task.

Purpose and Objectives

This study aims to investigate self-regulation in a collaborative design task, focusing on socially shared regulation. To achieve this overarching goal, the following objectives have been outlined:

- Explore how the structure of group interactions (e.g. communication styles, commitment levels) affect individual and shared self-regulation during a collaborative design task.
- Explore what role individual priorities, and teamwork dynamics play in shaping self-regulation during a collaborative design task.
- Explore how the iterative nature of the design task, with multiple rounds of task completion, influences changes in self-regulation over time.

Justification of Study

This research can improve understanding of self-regulation in collaborative tasks. The findings can inform educational practices, theoretical advancements, and personal development strategies.

The findings of this study have the potential to enhance our understanding of human behaviour, particularly in collaborative settings. Insights gained may improve collaborative learning practices, foster personal development, and inform educational policy (National Research Council, 2000).

Research Methodology

This study employs a mixed-methods approach. A survey is used to measure self-regulation, radar charts are used to further measure self-regulation and shared regulation. Data analysis involved statistical analyses to gain a comprehensive understanding of the role of self-regulation and shared regulation in a collaborative design task.

Methods

Participants

The participants of the study were 13 students from the University of Twente, of whom 4 were females and 9 were males. The researchers gathered the participants via their personal network. Participation in the study was voluntary, and all students consented to participate. The only requirement for this study was that all participants were at least 18 years old to be able to provide consent for themselves. All participants gave written consent to participate in the study. The consent form was created according to the guidelines of the Code of Ethics for Research in the Social and Behavioural Sciences Involving Human Participants. The UT Ethics Committee approved the study.

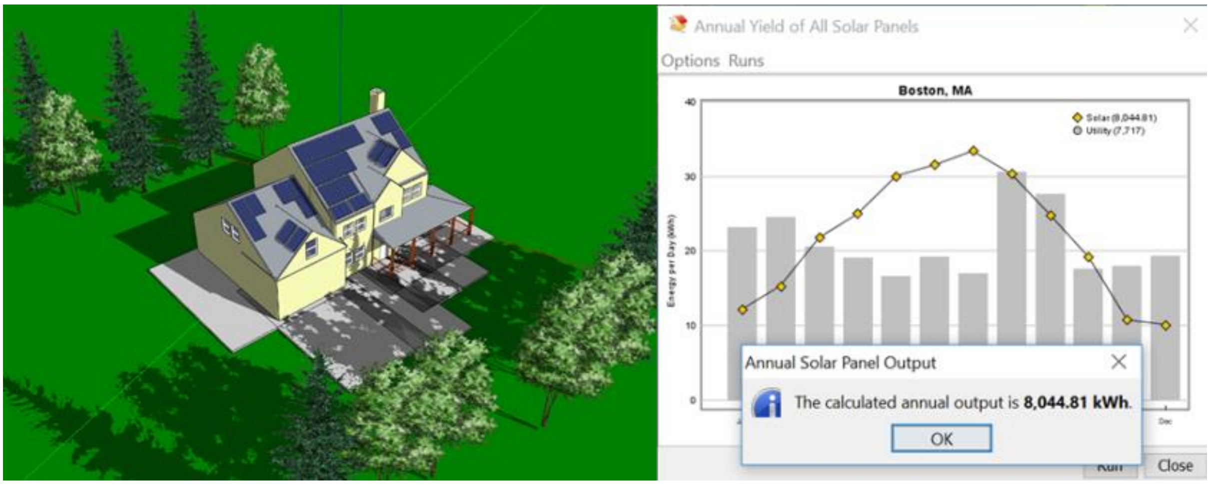
Design

For the study, participants fulfilled a design challenge in groups using the program Energy3D, a simulation-based engineering tool for designing green buildings and power stations (Xie et al., 2018). Users can easily design a realistic-looking house. The program can easily evaluate energy performance while considering the day, location, solar panels, trees, etc. Energy3D can generate graphs and other in-depth analyses to judge whether a house is net-zero (Figure 1.).

The participants worked in groups of 3-4 in a collaborative design task. In total, the session lasted approximately three hours. During the session, the participants fulfilled the design task three times (with the same groups). During all three turns, the participants were given a shared design task. The task was structured to push students to experience some uncertainty and encourage them to think creatively.

Figure 1.

Example of a Structure build in Energy3D and an Energy Analysis



In the challenge, participants were asked to design a net-zero house while staying within a set budget. A survey was used to measure self-regulation. The participants used smartboards to collaborate while using the program. They received the design prompt on paper and an information sheet containing information and ‘hints’ for fulfilling the task in case they ran into problems.

Procedure

Upon entering the room, participants were divided into groups. When all participants had arrived, the experiment was started. First, participants were asked to carefully read and sign the consent form after asking any questions. Second, participants were informed about the design task and asked to fill in the first part of the self-regulation questionnaire individually. After filling in the questionnaire, participants completed the first round of the design task in their groups. When the time allotted for the first round had passed, participants were asked to fill in a radar chart individually. After filling in the chart, they received the instructions for the second round of the design task. The same steps took place between the second and third rounds. After the last round, participants filled in the radar chart for the third time and filled in the second part of the self-regulation questionnaire.

In between rounds, participants were asked to fill in a radar chart to track individual self-regulation. After all participants had filled out the chart individually, the radar chart was shown on the screen. This means that the group can see a radar chart that is made of their combined answers and additionally all the answers from group members. This allows the group to see where it stands as a whole before starting the next round of the challenge, making the group aware of any challenges that may come up during the task.

Overall, the session took approximately three hours. Between rounds of task completion short 10 minutes breaks were given, where participants were allowed to walk around and leave the room. All groups performed the design task in the same room, they were separated but were able to hear/see the other groups if they tried.

Instruments

'Adaptive Instrument for Regulation of Emotions' (AIRE) was the survey used to capture participants' regulation processes during the collaborative design task. AIRE is composed of multiple sections. Section 1, completed before the design task, focuses on *personal task-specific goals*. The second section, filled out after the design task, focuses on experienced *socio-emotional challenges* by describing 14 possible challenges and asking participants to rate them on a 5-point Likert scale. The challenges used in the AIRE focus on the challenges that group members can face during collaborative tasks and the interactions that come along with the social interactions within the group. The individual answers from Section 1 and Section 2 can be sorted into five categories: *personal priorities, work and communication, teamwork, collaboration, external restraints* (table 1.)

Table 1.

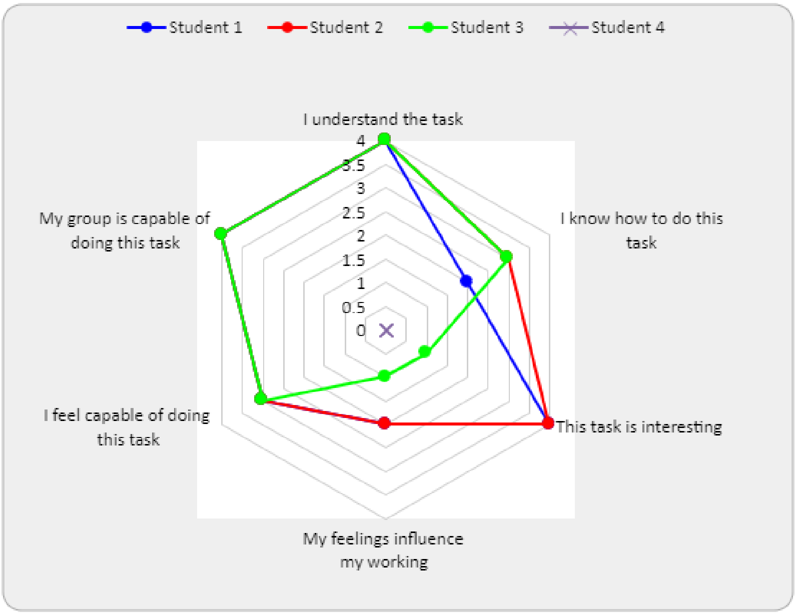
Challenge type in self-report data	Specific challenge scenario in self-report form
Personal priorities	A. Our goals for the project were different
	B. We had different priorities
Work and communication	C. We seemed to have incompatible styles of working
	D. We seemed to have different styles of interacting
	E. One/some people had problems with other students' accents and/or level of language proficiency and thought it was difficult to work with them
Teamwork	F. People in our group did not connect very well with one another
	G. One/some people were not fully committed to the group work
	H. People had very different standards of work
	I. Group members were not equal
	J. Some people were easily distracted
Collaboration	K. Our ideas about what we should do were not the same
	L. We differed in our understanding of the content/task
	M. Our conception of how to organize the work varies

External constraints	N. We had different personal life circumstances or family/study and work commitments

Note. The table was created by Järvenoja and Järvelä (2009)

A radar tool (see Fig. 2) was used to promote individual and shared self-regulation awareness. First, participants report individually about their self-regulation during the design task using four aspects (e.g., I feel capable of doing this task) and one aspect related to shared self-regulation (My group is capable of doing this task). In the radar chart, each of the axes represents one of the aspects: *I understand the task, I know how to do this task, this task is interesting, my feelings influence my working, I feel capable of doing this task, my group is capable of doing this task.*

Figure 2.
Example of Radar Chart Showing Individual and Shared Self-regulation



Data Analysis

Data analysis was done using R version 3.3.0 and Excel version 2312. All statistical analyses were done using R, a significance level of α = 0.05 was set for all tests to determine significance. Excel was used to regisrer data sets and calculate means.

AIRE analysis. Participants prioritized the most important challenge for their group, using the AIRE. The frequencies of the different challenge types from the questionnaire were calculated per group. During this research, we focused on the findings from section 2 of the questionnaire. A chi-squared test was performed across the two sections to test the distribution of the challenge types.

Radar analysis. Using the radar charts, participants reflected on their individual self-regulation and shared regulation. First, the mean was calculated per participant for their self-regulation and socially shared regulation. Additionally, a longitudinal mixed-effects analysis was performed. The analysis was done to investigate the effect of the iterative design on self-regulation over time with 'time_point' (i.e., round of task completion) as the independent variable and 'mean_individual' as the dependent variable. To this purpose, the lmer function was used from the lme4 package.

Results

AIRE results

Section 1 of the questionnaire was filled in before the design task. Section 2 of the questionnaire was filled in after the design task. Table 2 shows the frequency and proportion of the challenge types per group as they were mentioned by the participants. Among the challenge types, *teamwork* had the highest total frequency and proportion (16 and 61.5%). *Personal priorities, work and communication* and *collaboration* were reported at a lower rate with similar frequencies, making up 15.4%,11.5%, and 11.5%, respectively. No participants reported anything on *external constraints*.

Table 2.
Frequency and Proportion of the Different Challenge Types per Group

	Group A		Group B		Group C		Group D		Total	
	f	%	f	%	f	%	f	%	f	%
Personal priorities	0	0	1	12.5	0	0	3	50	4	15.4
Work and communication	2	33.3	0	0	1	16.7	0	0	3	11.5
Teamwork	4	66.7	5	62.5	5	83.3	2	33.3	16	61.5
Collaboration	0	0	2	25	0	0	1	16.7	3	11.5
External constraints	0	0	0	0	0	0	0	0	0	0
	6	100	8	100	6	100	6	100	26	100

Group A. The challenges for group A were spread between *work and communication* and *teamwork* (33.3% and 66.7%, respectively). Group A has the highest frequency for *work and communication* of all the groups (33% vs. 16.7%). *Teamwork* was the biggest challenge for group A, which aligns with the other groups.

Group B. The challenges for group B were split between *personal priorities, teamwork* and *collaboration* (12.5%, 62.5%, 25%, respectively). Group B is one of the two groups that mentioned *personal priorities* to be a challenge for them. *Teamwork* was the biggest challenge for group B. They have the highest frequency of all groups for *collaboration* (25% vs. 16.7%).

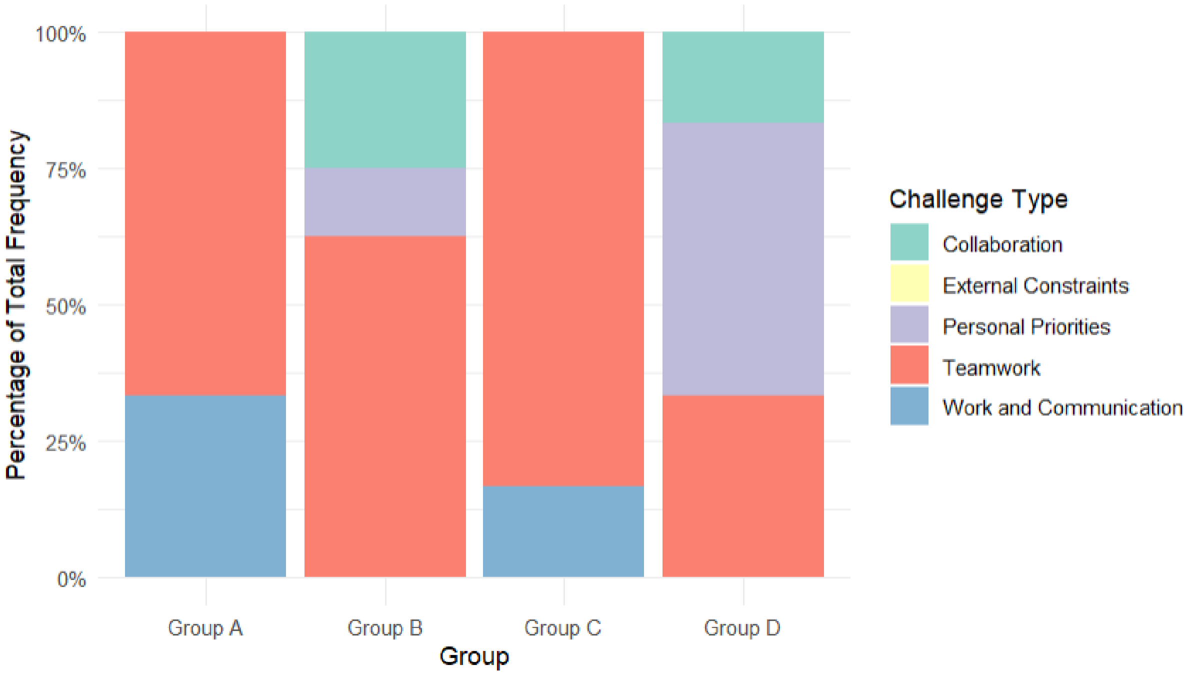
Group C. The challenges for group C were split between *work and communication* and *teamwork* (16.7% and 83.3%, respectively). Group C had the highest frequency of mentioning *teamwork* as their biggest challenge of all groups (83.3%).

Group D. The challenges for group D were split between *personal priorities, teamwork,* and *collaboration.* Group D has the highest frequency for *personal priorities* as their biggest challenge (50% vs 12.5%). They have the lowest frequency for *teamwork* out of all groups.

Figure 3 compares the frequency of challenge types across the groups. It can be seen that *teamwork* was the largest challenge for groups A, B, and C. Group D has the lowest frequency for *teamwork* but is the only group with a large challenge with *personal priorities*.

Figure 3.

Frequency of Challenge Types Across Groups



A Pearson's chi-squared test was conducted, it revealed a non-significant association between the distribution of the challenge types (χ^2=10, df=8, p= .265).

Radar charts results

Results of the mixed-effects analysis revealed a significant effect of 'time_point' (i.e., round of task completion) on 'mean_individual' (the individual level of self-reflection) (β = 2.5846, SE = 0.1427, t =18.116, p < .001). This indicates an increase in self-regulation over the rounds of task completion. Additionally, in the second and third round of task completion participants showed an increased level of self-regulation. As shown by the positive coefficients for the second measuring point (β =0.3231, SE = 0.1026, t = 3.148, p < .01) and the third measuring point (β =0.4154, SE = 0.1026, t = 4.047, p < .001).

A boxplot analysis (see Figure 4.) revealed a general trend of increase in the mean of individual self-regulation scores from the first to the subsequent rounds. Specifically, the first round showed the most similar scores for self-regulation. Round two showed an increase for groups A, B, and D, while group C had a decrease. Round three showed an increase for groups B and C and a similar score for groups A and D compared to round 2.

Figure 4.

Boxplot showing Mean Individual Self-Regulation Score per Group over the Rounds of Task Completion

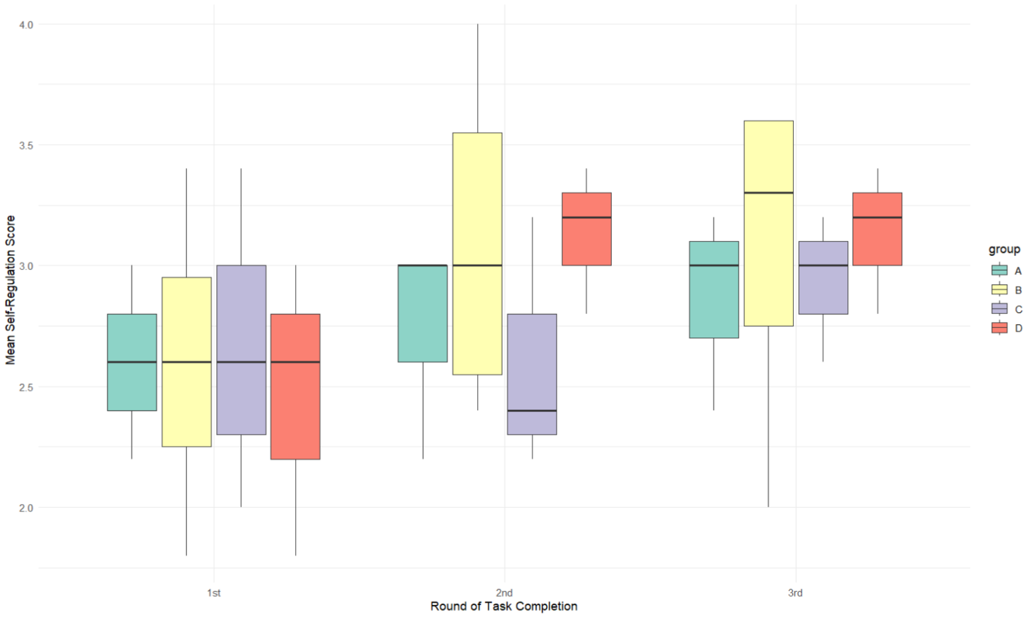
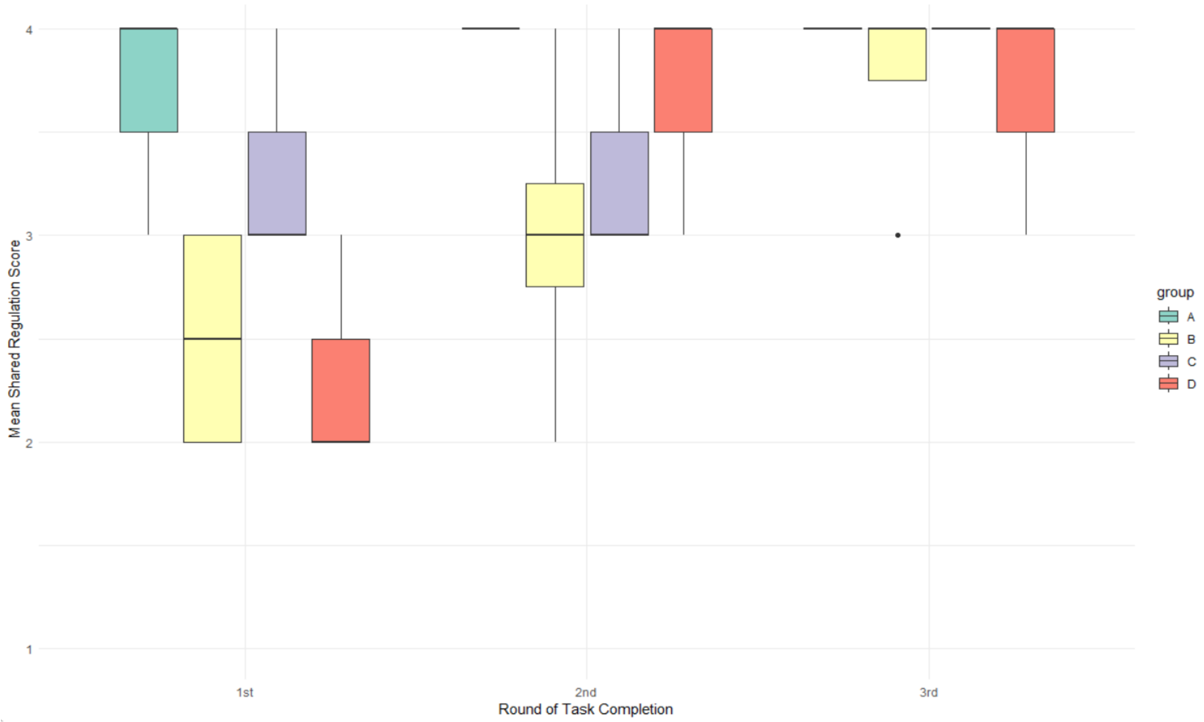


Figure 5 shows the mean of the shared regulation score per group over the rounds of task completion. It shows that group A had the highest possible score (4) for all rounds of task completion; only the first round showed a bit of spread, likely one person who rated the shared regulation lower. Group B showed a general increase over the rounds. Starting at a low score compared to groups A and C. Group C is the only group that showed no increase or decrease between the first and second rounds. For the third round, they increased to the highest score (with all group members giving the highest possible score). Group D showed the most significant difference between round 1 and round 2. They are the only group not to have an increased score between rounds 2 and 3. In general, Group A showed the highest score for shared regulation, and group D showed the lowest score.

Figure 5.

Boxplot showing Mean Shared Regulation Score per Group over the Rounds of Task Completion



Discussion

Principal findings

This aim of this study is to investigate self-regulation and shared regulation in a collaborative design task. Specifically, three research objectives were formulated:

Explore how the structure of group interactions (e.g. communication styles, commitment levels) affect individual and shared self-regulation during a collaborative design task. *Work and communication* were a challenge for Group A and Group C. Group A showed little change in their self-regulation and shared regulation scores. Group C showed little change in their shared regulation. The fact that the groups could overcome this challenge might be explained by the fact that they are all students. Education at the University of Twente is collaborative, with many different nationalities. The background of the participants might explain why a few groups had problems with communication.

Explore what role individual priorities, and teamwork dynamics play in shaping self-regulation during a collaborative design task. Results from the AIRE questionnaire revealed that teamwork was the biggest challenge for all groups. Specifically, Group C reported teamwork to be their biggest challenge. The radar charts showed that Group C saw the biggest decrease in self-regulation during the second round. Their inability to work together may explain the decrease in self-regulation. The problems with teamwork influence their ability to satisfactorily complete the tasks, which affects their self-confidence and, therefore, their self-regulation. Interestingly, group C's shared regulation stayed the same for the second and third rounds and increased slightly for the third round. While they had problems with teamwork, they still thought the group could complete the task.

Group D saw personal priorities as the biggest challenge of all the groups. This might explain why they had the lowest score for shared regulation after the first round of task completion. After discussing their radar chart of the first round, they could discuss their strategy for solving the task. Their answers for the individual self-regulation showed that they all thought themselves capable of the task but were not capable as a group.

These findings underscore the importance of addressing personal priorities. Addressing differences in collaboration can enhance teamwork dynamics and lead to higher levels of shared regulation.

Explore how the iterative nature of the design task, with multiple rounds of task completion, influences changes in self-regulation over time. The results demonstrated a significant increase in self-regulation over the multiple rounds of task completion. While the first round of task completion showed relatively uniform levels of self-regulation, participants showed higher scores in self-regulation as the task progressed. This suggests that the iterative practice in the task leads to the refinement of the cognitive processes that guide self-regulation.

Explanation of the results

The differences between group dynamics and their influence on self-regulation in a collaborative design task offer insights into the relationship between individual and shared regulation. Several factors can account for these differences: background of group members, interpersonal dynamics, different goals, and strategies used to handle the design challenge.

Firstly, the background of the group members, such as how familiar they are with each other and their academic and personal background, likely has an influence on the group dynamics and their approach to the task (Huang, 2018). For example, Group A and Group D showed relatively stable levels of self-regulation while encountering challenges such as *work and communication* and *personal priorities,* respectively. A pre-existing relationship or a shared interest in the group can explain this stability. This facilitated an effective collaboration and allowed for successful goal alignment.

On the other hand, Group B and Group C experienced challenges related to *teamwork,* which impacted their levels of self-regulation. Group B maintained an increase in self-regulation over the rounds of task completion. Group C also struggled with *teamwork.* However, where Group B did not experience challenges with communication, group C did. This can explain the relatively low scores for self-regulation; the inability to establish cohesive teamwork dynamics likely hindered their self-regulation, which led to their low scores on self-regulation in the second round. Group B's resilience could be explained by their effective communication or a shared commitment to solving the task while facing problems with *personal priorities* (Sonnenwald, 1996).

Moreover, the strategies that groups employed and their different goals for the design challenge influenced their self-regulation process (Hackman et al.,1976; Huber, 1985). For some groups, the focus may have been task completion; others might have focused on aesthetic design solutions or effective communication. The groups' overall self-regulation may have been shaped by these differing priorities.

Theoretical/practical application

In general, this research adds to the theoretical understanding of self-regulation in collaborative tasks, particularly in open-ended design challenges. These findings, in particular, show how factors such as teamwork, communication, and personal priorities affect self-regulation and shared regulation. Earlier research stresses that students use these different forms of regulation to maintain group dynamics (Frijda, 2005). Furthermore, this research emphasizes the importance of iterative learning processes. By examining changes in self-regulation across multiple rounds of task completion, the study shows the role of practice and experience in processes related to self-regulation in a collaborative setting. The discussion between rounds played a vital role in improving self-regulation, in line with the findings of Järvelä et al. (2014). Collaboration requires self-regulation and allowing team members to support their fellow team members to regulate their self-regulation Järvelä et al. (2014).

The insights from this research can help inform how to design and implement collaborative learning environments. Understanding groups' challenges in collaborative tasks allows educators to use targeted intervention strategies. Educators can develop interventions to support students in challenges related to communication, teamwork, and differences in personal priorities, which will ultimately foster a more welcoming environment for collaborative problem-solving.

Limitations

This study has certain limitations. Firstly, the study's sample size is relatively small, consisting of only 13 students. This small sample size may limit the generalizability to a broader population more diverse in age, ethnicity, and academic background. Second, the study focuses on collaborative design tasks conducted in groups. However, the groups may be homogeneous regarding prior relationships, academic background, or cognitive abilities. This may influence the group dynamics and self-regulation process, masking the differences in individual responses and limiting the validity of the findings. Thirdly, the study uses self-report measures to assess self-regulation and shared regulation. The instruments used may be subject to bias and social desirability. Fourthly, the study examines self-regulation and shared regulation within a specific design task using Energy3D software. The task is unique in its focus on energy-efficient building and simulation. Different tasks may lead to different self-regulation strategies and group dynamics. Lastly, the study consists of three rounds of task completion within one session. The short duration of the session may not capture long-term processes or fluctuations in self-regulation.

Future Research

Future research in this area could build upon the present study's findings. Firstly, expanding the sample size and participant diversity would enhance the findings' generalizability. Additionally, future studies could look towards longitudinal research design to investigate the long-term effects of collaborative design tasks on self-regulation and shared regulation. Longitudinal studies could show insight into potential moderators of self-regulation, such as differences in personality or motivational factors. Furthermore, future research could use experimental designs to investigate specific variables related to self-regulation and collaboration. For example, studies that target communication strategies, team-building exercises, or goal-setting techniques to combat the challenges revealed by groups using the AIRE to see their effect of self-regulation and shared regulation.

This study highlights the complexity of self-regulation and shared regulation in a collaborative design task. The study examined challenges faced by groups in a collaborative design task, and how these challenges affected self-regulation and shared regulation. Overall, this research has the potential to impact real-work applications in education, and a deeper theoretical understanding of self-regulation and shared regulation.

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