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Exploring the impact of self-regulated learning intervention on students' strategy use and performance in a design studio course

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Abstract
A growing number of studies indicate that self-regulated learning plays a significant role in students' academic achievement. However, research studies on design studio education in self-regulated learning are under-researched globally, including in Turkey. In this study, I developed a self-regulated learning intervention for industrial design studio education and examined its impact on students' self-regulated learning strategies and design performance. Twenty six third-year industrial design students were tracked in a mixed-method research study conducted during a design studio course. Following the study, quantitative and qualitative data were collected from the students using self-report questionnaires and interviews. The jury grades of the students in the experimental group were compared with the grades of the students in the control group. Integrated data analysis indicated that activities for promoting self-regulated learning strategies such as goal-setting, self-monitoring, self-evaluation, self-efficacy, and seeking help and information in design studios can assist design students to improve their strategy use and design performance.

Keywords Self-regulated learning · Industrial design · Design studio education · Design learning · Design performance

Introduction

Self-regulation consists of cyclical thoughts, feelings, and attitudes that individuals develop to help them reach their goals (Zimmerman, 2000). Since 1980, A growing body of literature has investigated self-regulated learning (SRL). Schunk (2014, as cited in Sakız, 2014) categorizes SRL studies into three eras—the developmental era, the intervention era, and the processing era—during which cyclical and dynamic SRL processes have been investigated. While digitalization link education and psychology to assessment, interventions, and the use of technology (Bembenutty et al., 2013), the rapid changes in learning environments require more studies.

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Multiple SRL models have been proposed based on various theoretical perspectives. Although their focus is different, all the models refer to self-regulation as a phenomenon that includes certain processes (e.g., preparation, realization, and post-evaluation) and occur in different dimensions (cognitive, metacognitive, motivational, and behavioral, among others (Sakız & Yetkin-Özdemir, 2014). Within the various theories and models, Bandura's research findings and Zimmerman's implementation of the social cognitive approach are the most frequently cited in the literature (Oz, 2019). According to Schunk and Usher (2013, as cited in Sakız, 2014), Zimmerman's SRL model is the best example of a model in which both process and component-oriented classifications co-exist in one approach. Panadero (2017) compares different models and asserts that Zimmerman's model has been more frequently cited because it includes a greater number of specific subprocesses that provide a comprehensive vision. Therefore, Zimmerman's social cognitive model may prove to be more helpful when researching creative tasks or processes in different learning environments (Rubenstein et al., 2018).

Students who self-regulate their learning process are active in their learning. Using metacognitive, behavioral, and motivational strategies, they proceed through three cyclical phases (Zimmerman, 2002; Zimmerman & Pons, 1986). Zimmerman (2000) expands on the notion of the student's feedback loop which is a central feature of academic learning and includes the phases of forethought (before the study), performance (during the study), and self-reflection (after the study) (Zimmerman, 1989; Zimmerman & Cleary, 2009). Each phase covers a set of procedures that a person may employ when seeking to learn, improve, or perform a skill. Each phase is expected to impact (or feed) the next phase (Rubenstein et al., 2018). The model has multiple sub-processes with significant in-between correlations (Zimmerman, 2008).

The theoretical framework Bandura proposed for self-regulation has a process-oriented approach (Wirth & Leutner, 2008), which focuses on the actions and events that enable self-regulation and examines what the person did or should do during these actions (Ader, 2014). The interaction between personal, behavioral, and environmental processes is consistently intertwined; at any one time, one or more of these elements may exert a greater effect than the others (Thomas, 2013). A different learning environment can cause a learner's SRL skills to alter, therefore learners should be expressly encouraged to develop SRL abilities. As a learning environment with quality process-oriented and collaborative facilities, instructors at a design studio need to consider the relationship between students and the context. A social-cognitive perspective provides a design studio learning environment with an appropriate foundation for learners' varying internal and external factors. In this study, I did not attempt to provide an analysis of all SRL theories or models and the advantages of each. Rather, I employed Zimmerman's (2000) model to show how design learning in the studio might be included in the SRL framework.

Design Studio and Self-Regulation

University students need to be independent learners with the capacity to plan, monitor, and evaluate their work and control their motivations and emotions (Vosniadou, 2020). Some professions demand these skills using different approaches, creating characteristic forms of teaching and learning. Shulman (2005) defines these unique preparations for the professions as "signature pedagogies" and describes their characteristics as having three levels: (a) a surface structure of teaching and learning activities, (b) a deep structure of

assumptions about transferring a particular piece of knowledge, and (c) an implicit structure of a moral dimension, including professional beliefs, values, and attitudes. These three aspects affect the ability to think and act like a professional (Shulman, 2005), which is the main goal of higher education. Professionalism also includes dealing with the uncertainties that signature pedagogies contain. Every professional must provide skills to manage and balance the intrinsic tension of having to make judgments under uncertain situations (Shulman, 2005).

Design studio education is one of these signature pedagogies with its distinct pedagogical method (Shreeve, 2015; Shulman, 2005; Zairul, 2018) that includes learner-centered activities, knowledge construction through interaction, and the studio as a social environment (Yorgancioglu, 2020). Design as a discipline involves a highly organized mental process related to manipulating and blending many kinds of information into ideas and generating their realization (Lawson, 1980). It usually starts with a project brief which includes the conditions, needs, or restrictions about the subject. This text is then transformed into an experiential or tangible output. While this transformation requires a high-level cognitive process including several stages of information analysis and synthesis (Lawson, 2005), learning to design to deal with complex problems requires relatively more advanced knowledge levels (Ertmer & Newby, 2013). In the design pedagogy literature, the interactional relation in design studio mostly unfolds over one-to-one conversations between student and instructor (e.g., Goldschmidt et al., 2010; McDonald & Michela, 2019; Oh et al., 2013; Peterson, 1979; Uluoğlu, 2000). This is one of the features of design studio that sets it apart from lectured class format.

The term *studio* in the design education refers to both the physical space where students and instructors meet and the pedagogical approach applied within it (Crowther, 2013). Two main stimuli help students to sustain their design learning in studio: the individual way of students approaching their design and the pedagogical way of instructors feeding back to students' design (Kowaltowski et al., 2010). The individual approach of a student is developed progressively through repeated design exercises, largely based on trial–error and feedback (Casakin & Goldschmidt, 1999). Design students are expected to develop solutions and bring them to the studio showing weekly progress to discuss with the instructor or sometimes with peers and guests (Goldschmidt et al., 2010). It requires students to study and develop creative ideas by themselves and this necessitates a profound cognitive process. In these individual self-study times, they are expected to criticize their own work and make progress, which also involves behavioral and motivatinal factors. Hence, self-regulation is one of the important progressive tools in the design learning process.

The pedagogical approach is the second stimuli that influence developing skills and self-perception (Yorgancioglu & Tunalı, 2020). The tacit form of design knowledge and the different ways in which designers choose to acquire this knowledge make it impossible for design instructors to develop a specific teaching strategy (Ozdemir, 2013). Interaction with the instructors as experienced professionals through unstructured talks about the design challenges are key components of this instructional approach (Kowaltowski et al., 2006). Instructors provide feedback on the students' work, and students need to respond to that in each class and juries in which students present their projects. Feedbacks help students to move forward while developing their projects and iteratively provide them with a constructive learning process (Tovey, 2015). Nevertheless, conversation between the student and the instructor centers around the student's work (Schön, 1985). Thus, students are the main actors and are fully responsible for constructing self-knowledge. They need to have a good self- understanding and self-evaluation about the various stages of their designing process (Almendra & Christiaans H., 2011).

This critical and self-constructive process may create challenges for novice students who struggle to engage with the design learning context. Additional capacity and motivation are required by them to deal with the unpredictable and serendipitous studio environment (Crowter, 2013) and the ambiguous pedagogy (Austerlitz et al., 2008). Even though studio instructors encourage students to reflect on their creative process to self-regulate their learning (Greene et al., 2019), neither instructors nor students in design studios are fully aware of SRL strategies. Leading a novice to attempt design learning environment entails a more social and cognitive approach to sustain students in going beyond their capability and self-understanding. There is a fundamental lack of educational learning theories in design education since design learning has not been extensively studied from a cognitive perspective (Oxman, 1999). More research is needed for a comprehensive understanding of design learning with its personal, behavioral, and environmental factors.

When we consider the intense cognitive and social processes in design studio, the social-cognitive learning theorem provides an appropriate foundation for studying design learning. There are a limited number of studies on SRL in design studio education and they generally focus on components of self-regulation such as metacognition or motivation (see Hargrove, 2007, 2011; Kavousi, 2017; Kavousi et al., 2019, 2020; Oluwatayo et al., 2015) or a single aspect of SRL such as peer review (Zairul, 2018). The exception is Powers (2006, 2016) who researched SRL in the design studio. He proposed an SRL methodology for design education incorporating the process of design learning. However, the lack of an intervention study to evaluate the assumptions limit this study. It should be said that even the limited number of studies contain valuable insights on SRL in design studios. Industrial design (ID) studios have their domain-specific dynamics and therefore a deeper understanding of the SRL approach is needed. In this study, I address this need for a deeper understanding by studying the effects of SRL strategies (e.g., the intervention) on design students within an experimental design framework.

Developing SRL Strategies

Existing literature has illustrated that support for SRL noticeably nourishes strategy development in learning environments such as STEM, history, and language, among others, (see Azevedo & Cromley, 2004; Masui & de Corte, 2005; van den Boom et al., 2007; Zimmerman & Kitsantas, 1997). These studies focus on applying an SRL model, designing a new model, or developing and validating self-regulation scales. Jivet et al.'s (2018) study on thirteen different SRL tools indicates that SRL can be supported through tools that provide awareness for learners and trigger reflection on the learning process. Nevertheless, more evaluations are needed to understand the characteristics to be considered in designing new tools, since few if any guides on this topic are available (Pérez-Álvarez et al., 2016).

According to the studies on successful interventions, the common elements required are as follows: discipline-oriented content (Hattie et al., 1996; Perels et al., 2009); implementation by the class teacher (Ader, 2014); scaffolding and faded support for students (Greene, 2018); direct and explicit promotion of, and information on, SRL (Kistner et al., 2010). To sum up, for success in SRL development, discipline-focused interventions should be implemented by classroom teachers who provide faded support along with explicit information on SRL. Accordingly, the intervention in this study was designed with attention to the recommendations defined above.

Research Methodology

Research Design

This study is a follow-up intervention application of an earlier exploratory study investigating the differences in the SRL strategies used by design students (see X). The main purpose of this study was to determine how SRL interventions in a design studio affect students' use of SRL strategies and design performance. I used a quasi-experimental research design framework and mixed-method approach in which both qualitative and quantitative data were collected.

In experimental design research, the independent variable or variables are manipulated to determine its/their effect on the dependent variable/s (Teddlie & Tashakkori, 2009). In this study, I used a predetermined intact group of design students studying at a university. All the students underwent the regular studio process, except for the students in the experimental group who practiced SRL interventions. Since participation was voluntary, the research design in this study was quasi-experimental (Campbell & Stanley, 1963).

Participants and Setting

Thirty seven ID students from the same third-year studio class participated in this study. All students were asked, via email, if they wanted to join this working group. They were also told they would be provided with study information, and that their participation would remain confidential. Eleven students volunteered for the intervention. They were on average 20.9 years old (SD = 1.2), enrolled in the fifth semester, and native Turkish speakers. Therefore, the intervention was offered in Turkish. The remaining 26 students were assigned to the control group. Since SRL focuses on individual learning development, the intervention sessions were carried out during the individual project development phase. The mid-term jury was included during the sessions since it was used as a self-evaluation tool. Therefore, the intervention was conducted from the 5th to the 9th week of the 14-week term. Due to the Covid-19 pandemic, all educational activities had to be shifted to digital platforms, referred to as *emergency remote learning* because the courses were not built for online delivery originally (Winters, 2021). Teachers had little time to prepare and pupils had to quickly adapt to online sessions. Similarly, the emergency remote studio was a digital version of the physical studio. In the studio in this study, instructors and students interacted virtually using video conferencing platforms. Students presented their work on a computer or paper, received criticism from professors and peers, and were expected to study during the four-hour or longer online session. The instructor's absence gave students the impression that time and space were flexible in the virtual design studio. In this unfamiliar terrain, students could easily stop paying attention. Since self-regulated learners need less of a teaching presence (Pool et al., 2017), supporting design students with SRL strategies can help improve their use of time in the virtual studio. Due to these practical changes, the intervention study was developed and executed online. The content of the study was developed based on the content and examples from pre-exiting online and regular classroom interventions and customized to the emergency remote studio environment.

The Content of the Intervention

The content of the intervention in the emergency remote ID studio was based on prior studies on design studios and Zimmerman's (2000) SRL process model. It consisted of four sessions. Three sessions were developed based on the SRL model's three phases, and the fourth session served as a reminder of the process loop. Table 1 shows the content and process of the intervention study.

Design students' reliance on studio instructors and other external factors hinder their progress (Ates-Akdeniz & Turan, 2022). The first session of the intervention was intended to be a break point when students became aware of their dependence on others. Students were encouraged to ask questions about their studio experience and to set goals. During the intervention, students were given explicit self-regulation strategies and learning tools and informed about the SRL phases. The project brief was reread and the learning outcomes and evaluation criteria were discussed. Students were then asked to describe their design process and prioritize their goals and plans via an online questionnaire.

In a design studio, motivation is another factor that is constantly being tested. Unfair public criticism could cause students to lose confidence in their design abilities (Powers, 2006). Low-achieving design students in particular prize studio success as positive critique and are vulnerable to harsh criticism (Ates-Akdeniz & Turan, 2022), to which they may respond by losing interest in their studies. Low-achieving design students also tend not to seek help from others to avoid feeling demoralized. The second session of the intervention targeted these flaws.

In the intervention study, students discussed their goals and plans in the first session. This discussion was aimed at developing peer interaction, which can improve self-efficacy as students share comparable issues and learn from one another. Another direct SRL topic was individual differences. Students were encouraged to continue using their learning styles to develop self-confidence. Later, during the metacognitive monitoring activity, students' strengths and weaknesses, as per the studio's assessment criteria, were discussed. Finally, students were asked to fill out an online questionnaire answering questions such as "How to get an A in the design studio"? Nilson (2013) proposed this question as an SRL activity for underperformers to help them learn why and where they failed and how they could improve their learning methods. Making a connection between success and effort is defined as an instructional approach that promotes SRL (Paris & Paris, 2001; Sungur & Gungoren, 2009). Therefore, this question was meant to motivate design students to think about success criteria and compare their performance against them.

Microteaching is a pre-teacher education technique that uses a video recording of a scaled-down lesson conducted by a pre-teacher to use later as an evaluation tool. Preservice teachers examine their video-recorded microlessons with colleagues and instructors to assess, reflect on and develop their teaching skills (Ostrosky et al., 2013). This process, which includes playing and replaying the recording, is intended to improve preservice teachers' learning experience by providing detailed feedback (Brent et al., 1996), identifying strengths and weaknesses, and highlighting mistakes (Marulcu, 2014). The third session's content was created using this video recording method to encourage self-criticism among design students. Students were asked to watch their recorded mid-term jury presentation on Zoom and fill out a series of self-evaluation questionnaires. Criticism and feedback, based on the evaluation criteria of the mid-term jury and from peers were analyzed by the researcher. Each student's prior presentation performance was also discussed during this feedback session.

Table 1 The content and process of the intervention study

Process	Content
Ethical permissions	
SSRL questionnaire	Administering the scale on self-regulation in learning (SSRL), a self-report questionnaire to all 3rd-grade ID students
Research Jury	
Announcement	E-mailing invitation posters and initial information about the process
The working group	Arranging working groups and sending out the announcement for the first session
1st session	**Goal Setting and Planning in the Studio (Part of the Forethought Phase of SRL):** Students introduce themselves Introduction to learning How does learning take place in the studio? Thinking and writing about the project process in the studio What are the SRL and SRL loops? When and how is SRL used? What is the effect of motivation? How to implement SRL in the studio Task Analysis: Re-reading the brief of the project Discussing the learning outcomes and evaluation criteria Goal setting and planning practice: Questionnaire 1
2nd Session	**Self-observation in the Studio (Part of the Performance Phase of SRL):** Discussion of the answers in questionnaire 1 Discussion of individual differences in learning Reflection on the individual learning process: How do I learn? Metacognitive Monitoring: Self-observation My belief in myself in this project (avg. 3.2/5) In which subject do I feel successful, strong, or lucky? At what point do I feel unsuccessful, powerless, unlucky? Developing the weakest point: Questionnaire 2
Midterm Jury	
3rd session	**Self-evaluation in the Studio (Part of the Reflection Phase of SRL):** Watching self-presentation and commentary records of the mid-term jury Answering the questions: – How do I feel after the jury? – Commenting on presentation and comments – The strongest part of my project – The weakest part of my project Self-evaluation of the mid-term jury: Questionnaire 3-a Re-planning after mid-term jury: Questionnaire 3-b One-to-one process tracking: My design process
4th session	**The Loop of SRL** Practice thinking on the project process: – What did the studio want from me? – What was my purpose? – Where am I in my project, what am I doing? – What subjects am I bad at, and what can I do better? – What will I do now? Activities on Miro application: – Collective activity: What do you need to be successful in the project? Individual activity: Process follow-up of *My design process,* the 5-day & 5-week plan

The SRL method emphasizes individuality. Students should be aware that each learning activity is their own and should be identified, tried, evaluated, changed, and improved. The fourth session of the intervention was designed to help students comprehend the SRL loop and show them how to use it in practice. They were prompted to think about the project using Miro, an online collaborative whiteboard. Using Miro, students created individual boards with their ideas on success criteria and discussed them on a general board. Afterward, they planned and discussed their five–day-week goals with the researcher individually. Thus, students were instructed to create new goals and plans based on their earlier SRL loop reflections.

Data Collection

Assessing and developing SRL skills has not been sufficiently explored. Although researchers have shown that self-report measures like questionnaires and interviews are reliable and useful in monitoring SRL strategies (Roth et al., 2016), utilizing a single measure has been criticized since it limits the ability to assess multiple learning strategies (Perry, 2002). Employing multiple methods to investigate SRL helps researchers build theory inductively (Butler, 2002). This intervention study sought two research questions: (1) What is the impact of SRL intervention on students' awareness and use of SRL strategies? (2) What is the impact of SRL intervention on students design performance in

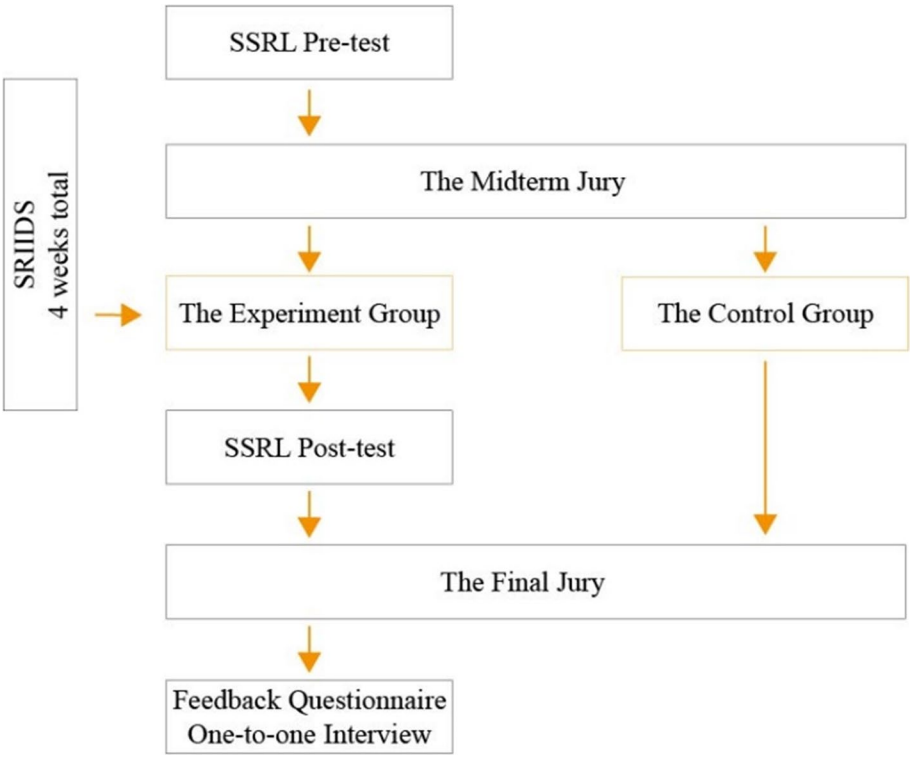

Fig. 1 The research design

the studio. To answer these questions both quantitative and qualitative methodologies were employed. Figure 1 depicts the research design.

To evaluate the influence of the intervention study on students' awareness and usage of SRL methods, a mixed-method design was used to collect both quantitative and qualitative data. To measure quantitative data, the "Scale on Self-Regulation in Learning" (SSRL), a self-report questionnaire developed by Erdogan (2012) was used before and after the intervention study. The experimental group's pre- and post-test scores were compared to evaluate how the intervention affected students' use of SRL strategies. After the intervention, students in the experimental group were interviewed to assess their engagement with and awareness of SRL methods. The interviews were guided by a semi-structured interview protocol. The questions were designed to urge participants to elaborate on the intervention's efficacy in regulating their learning.

To understand the intervention's impact on students' design performance, the experimental and control groups' jury grades were tracked and compared. Designing is a process that transforms the designer; this transformation is a dimension of learning (Findeli, 2001). Therefore, each student was graded for both the design process and the design outcome. Students studied individually during the concept development and design development phases including the mid-term and final juries. To measure the effects of the intervention on students' design learning process, students' grades on the concept development process, design development process, participation, and also their midterm and final jury, and term grades were factored into comparison tests.

Quantitative Analysis and Results

SSRL Self-Report Questionnaire

Th**E** SSRL pre and post-test scores were compared statistically. Pre-test Cronbach's alpha coefficients were 0.88 for the whole scale, 0.87 for self-regulated learning skills, and 0.88 for motivation. Post-test Cronbach's alpha coefficients were 0.85 for the whole scale, 0.82 for self-regulated learning skills, and 0.86 for motivation.

Table 2 shows the descriptive statistics of all variables. The pre-test total score was 224.55 (SS = 20.7) and the post-test total score was 246.45 (SS = 15.9). The pre-test SRL mean was 151.64 ± 15.8 while the post-test SRL mean was 176.73 ± 13.4. The motivation mean was 72.91 ± 9.87 for the pre-test and 78.73 ± 9.79 for the post-test.

The Wilcoxon signed-rank non-parametric test was performed to assess for a statistically significant difference between pre-and post-test scale scores since each group's sample size was less than thirty (N = 11, N = 26). As presented in Table 3, the results revealed that total SSRL scale scores were found to be statistically significantly higher in post-tests ($Mdn = 248$) than in pre-tests ($Mdn = 218$), $T = 0.00$, $z = -2.940$, $p < 0.003$. In addition, the SRL total scores of the students were found to be statistically significantly higher for the post-test scale ($Mdn = 166$) than for the pre-test scale ($Mdn = 149$), $T = 0.00$, $z = -2.937$, $p < 0.003$. Furthermore, motivation total scores of the students were found to be statistically significantly higher for the post-test scale ($Mdn = 67$) than the pre-test scale ($Mdn = 59$), $T = 1$, $z = -2.501$, $p < 0.012$. There was also a statistically significant difference in pre-and post-test scores for various sub-dimensions such as planning, seeking appropriate information, self-monitoring, self-evaluation, self-consequences after success, and self-efficacy.

Table 2 Descriptive statistics of pre-and post-test scale results

SSRL dimensions	Tests	N	Number of items	Mean	Std. deviation	Minimum	Maximum
SSRL total	Pre-test	11	67	224.55	20.729	205	258
	Post-test	11	67	246.45	15.977	222	274
SRL total	Pre-test	11	45	151.64	15.870	126	175
	Post-test	11	45	167.73	13.417	150	188
Motivation total	Pre-test	11	22	72.91	9.874	56	92
	Post-test	11	22	78.73	9.799	68	96
Before study	Pre-test	11	13	44.64	5.085	36	51
	Post-test	11	13	49.00	4.796	41	55
During Study	Pre-test	11	19	60.09	7.752	50	72
	Post-test	11	19	68.18	7.360	58	78
After study	Pre-test	11	13	47.64	6.217	35	56
	Post-test	11	13	51.36	7.159	33	61
Arrangement of study time	Pre-test	11	4	12.55	2.162	9	16
	Post-test	11	4	12.91	2.119	9	15
Planning	Pre-test	11	5	15.91	2.212	12	19
	Post-test	11	5	18.09	3.419	13	22
Environmental structuring	Pre-test	11	4	16.18	2.601	13	20
	Post-test	11	4	18.00	1.789	16	20
Organizing and transforming	Pre-test	11	5	17.09	4.847	11	24
	Post-test	11	5	19.00	4.000	14	24
Seeking appropriate information	Pre-test	11	3	9.18	1.991	6	13
	Post-test	11	3	11.45	1.635	9	14
Seeking easily accessible information	Pre-test	11	2	3.82	1.722	2	7
	Post-test	11	2	4.00	1.897	2	7
Rehearsing and memorizing	Pre-test	11	4	12.55	2.162	8	16
	Post-test	11	4	13.55	2.544	10	18
Self-monitoring	Pre-test	11	2	5.91	3.015	2	9
	Post-test	11	2	8.09	1.640	5	10
Seeking peer. teacher or adult assistance	Pre-test	11	3	11.55	2.252	6	13
	Post-test	11	3	12.09	1.973	8	15
Self-evaluation	Pre-test	11	6	24.36	3.295	20	30
	Post-test	11	6	25.55	4.591	16	30
Self-consequences after success	Pre-test	11	4	11.00	4.313	4	17
	Post-test	11	4	13.45	2.945	8	17
Self-Consequences After failure	Pre-test	11	3	10.55	3.475	5	15
	Post-test	11	3	11.55	2.115	9	15
Self-efficacy	Pre-test	11	5	18.27	3.524	14	23
	Post-test	11	5	21.09	1.758	18	23
Goal orientations	Pre-test	11	3	10.27	2.102	7	14
	Post-test	11	3	10.18	3.430	4	15
Task value	Pre-test	11	5	19.73	4.077	14	25
	Post-test	11	5	21.27	3.663	14	25
Attributions for failure	Pre-test	11	4	10.82	3.281	7	17
	Post-test	11	4	10.73	3.690	8	18

Table 2 (continued)

SSRL dimensions	Tests	N	Number of items	Mean	Std. deviation	Minimum	Maximum
Anxiety	Pre-test	11	5	13.82	3.341	9	20
	Post-test	11	5	15.45	3.908	11	22

Grade Comparison

The Mann–Whitney U test was used to test whether there were significant grade differences between groups. The intervention was completed after the mid-term jury and design development process. The test results revealed that the final jury grades (mean rank = 24.05, U = 87.5, z = –1.488, $p < 0.035$), participation grades (mean rank = 23.41, U = 94.5, z = –1.651, $p < 0.042$), and term grades (mean rank = 22.18, U = 108.0, z = –1.166, $p < 0.024$) of the students in the experimental group were statistically higher than that of the students in the control group (see Table 4). This could signify that the intervention had a positive impact on students' design process. These findings support my supposition that the SRL intervention would help students to improve their academic achievement, including in the design studio. However, it remains unclear to which degree the increase in the grades can be attributed to the SRL intervention. Therefore, more data analysis will be required to determine the assumptions underlying this study and the validity of the results.

Another Wilcoxon signed-rank test was run to see if the experimental group's grades changed significantly before and after the intervention study. The mid-term and final jury grades were utilized because they were graded similarly and their timing was suitable for pre and post-comparison. As shown in Table 5, the difference in the mid-term (Mdn = 60.0) and final jury grades (Mdn = 72.6) of the students in the experimental (intervention) group are statistically significant T = 0.00, z = –1.689, $p < 0.04$. This means that participant students' final jury grades were an improvement on their mid-term grades.

Qualitative Analysis and Results

The answers given by the 11 interviewees were analyzed using the content analysis method, which classifies data without any theoretical assumptions (Elo & Kyngäs, 2008; Schilling, 2006). The analysis process was conducted in three phases—preparation, organizing, and reporting (Elo & Kyngäs, 2008). In the preparation phase, the questions were converted into headings and the codes were derived from the students' answers via open coding. General views on the intervention, activities, and students' self-comments were the main categories. During the organizing phase, the coding scheme, shown in Table 6, was developed. In the reporting phase, the frequency of the use of these categories in students' interviews and direct quotes were included. The MAXQDA'20 qualitative data analysis program was used for all three phases.

In qualitative research, reliability is defined as the consistency of data code groups derived by multiple researchers (Creswell, 2014). Therefore, the researcher collaborated with another scholar on the content analysis. Because several codes were incompatible, they were then grouped with other categories or eliminated and the reliability of coders

Table 3 Wilcoxon test results of pre-and post-tests' scale scores

SSRL dimensions	Negative ranks			Positive ranks			Test statistics		
	n	Mean rank	Sum of ranks	*n*	Mean rank	Sum of ranks	Ties	Z	Asymp. Sig. (2-tailed)
SSRL total	11	6.00	66.00	0	0.00	0.00	0	–2.940[b]	**0.003***
SRL total	11	6.00	66.00	0	0.00	0.00	0	–2.937[b]	**0.003***
Motivation total	8	6.50	52.00	2	1.50	3.00	1	–2.501[b]	**0.012***
Before study	9	5.83	52.50	1	2.50	2.50	1	–2.555[b]	**0.011***
During study	11	6.00	66.00	0	0.00	0.00	0	–2.947[b]	**0.003***
After study	9	5.72	51.50	1	3.50	3.50	1	–2.469[b]	**0.014***
Arrangement of study time	3	3.33	10.00	2	2.50	5.00	6	–.677[b]	0.498
Planning	7	5.71	40.00	2	2.50	5.00	2	–2.101[b]	**0.036***
Environmental structuring	7	4.00	28.00	0	0.00	0.00	4	–2.388[b]	0.317
Organizing and transforming	6	6.25	37.50	3	2.50	7.50	2	–1.799[b]	0.072
Seeking appropriate information	9	5.00	45.00	0	0.00	0.00	2	–2.701[b]	**0.007***
Seeking easily accessible information	2	1.50	3.00	0	0.00	0.00	9	–1.414[b]	0.157
Rehearsing and memorizing	6	7.75	46.50	5	3.90	19.50	0	–1.209[b]	0.227
Self-monitoring	8	4.50	36.00	0	0.00	0.00	3	–2.539[b]	**0.011***
Seeking peer. Teacher or adult assistance	5	4.60	23.00	2	2.50	5.00	4	–1.561[b]	0.119
Self-evaluation	5	3.90	19.50	3	5.50	16.50	3	–.213[b]	**0.031***
Self-consequences after success	6	5.50	33.00	2	1.50	3.00	3	–2.108[b]	**0.035***
Self-consequences after failure	5	4.20	21.00	2	3.50	7.00	4	–1.190[b]	0.234
Self-efficacy	7	4.00	28.00	0	0.00	0.00	4	–2.375[b]	**0.018***
Goal orientations	4	5.25	21.00	5	4.80	24.00	2	–.178[c]	0.858
Task value	6	5.17	31.00	2	2.50	5.00	3	–1.845[b]	0.065
Attributions for failure	4	5.25	21.00	5	4.80	24.00	2	–.181[c]	0.856
Anxiety	8	4.88	39.00	1	6.00	6.00	2	–1.970[b]	0.049

Bold values indicate the significance of $p < .05$

[b]Based on positive ranks; [c]Based on negative ranks

Table 4 Mann–Whitney U test results for between groups

Grades	Groups	N	Mean rank	Sum of ranks	Mann–Whitney U	Wilcoxon W	Z	Asymp. sig. (2-tailed)
Concept dev process	Experimental	11	23.41	257.5	94.5	445.500	–1.613	0.107
	Control	26	17.13	445.5				
Mid-term jury	Experimental	11	17.91	197.00	131.000	197.000	–0.402	0.688
	Control	26	19.46	506.00				
Design dev process	Experimental	11	19.73	217.00	135.000	486.000	–0.266	0.790
	Control	26	18.69	486.00				
Final jury	Experimenal	11	24.05	264.50	87.500	438.500	–1.488	**0.035***
	Control	26	16.87	438.50				
Participation	Experimental	11	23.41	257.50	94.500	445.500	–1.651	**0.042***
	Control	26	17.13	445.50				
Term grade	Experimental	11	22.18	244.00	108.000	459.000	–1.166	**0.024***
	Control	26	17.65	459.00				

Bold values indicate the significance of $p < .05$

Table 5 Wilcoxon signed-rank test results within the experimental group

Juries	Negative ranks			Positive ranks			Test statistics		
	n	Mean rank	Sum of ranks	*n*	Mean rank	Sum of ranks	Ties	Z	Asymp. sig. (2-tailed)
Pre-tests (Midterm Jury) – Post-tests (Final Jury)	3	4.67	14.00	8	6.50	52.00	0	–1.689	**0.04***

Bold value indicate the significance of $p < .05$

Table 6 The coding scheme of the content analysis

1.0 General views of students on the SRL intervention
1.1 A useful activity
1.2 Time to analyze yourself
1.3 Good timing in the studio process
1.4 "I was not alone"
1.5 Comfortable environment
1.6 Earlier need in university life
2.0 General views of students on the activities practiced in the SRL intervention
2.1 Setting and achieving goals
2.2 Project analysis/rereading the brief
2.3 Project analysis/replaying mid-term records
2.4 Most useful activity: miro
3.0 Students' comments on themselves after the SRL intervention
3.1 Strategy development
3.2 Increase in self-confidence
3.3 Influenced by peers
3.4 Continuity
3.5 Learning experience

to create themes was agreed upon by each coder. Inter-coder reliability is defined as the ratio of the sum of agreements to all agreements and disagreements amongst coders (Miles & Huberman, 1994). The inter-coder reliability of the researcher's and the expert's themes and codes was 83%. To obtain a clear picture of the participants' opinions, direct statements from them were required.

This section includes key findings on the students' engagement in the intervention study. The content analysis yielded three main themes: views on the intervention, views on the activities, and students' self-comments after the intervention. The letters and numbers in parentheses (P1, P2, etc.) indicate students whose statements were directly quoted in Tables 7, 8 and 9.

The Views on the Intervention

Students were asked about their general opinion on the intervention study. As shown in Table 7, their answers were grouped under six main categories.

The study appears to have benefited the participants. Students' consensus was that the project's intensity overrode their wishes and feelings. They could go forward by focusing on their goals when they had time to analyze themselves. Eight of them called the study "self-analyzing time," and said that the feeling of "I'm not alone" made them feel more comfortable while self-evaluating. This shared experience provided a friendly and sympathetic environment where students could express themselves and pursue self-directed goals. Seven students compared the study to the studio and said they could express themselves more freely. It was observed that the students need communication at this level during studio hours, too.

Nine students' responses indicate that the timing of the intervention was helpful since it took place before the studio starts, a period that is typically stressful, uncertain, and

Table 7 General opinions about the intervention

Categories	*f*	Student expressions
A useful activity	11	"I don't see it from the point of view of the grade. It was useful, I started to think about something about myself, about what I want, about the future. For example, I am planning to spend more time on coding." (P1) "It was very useful for me, I felt that I improved myself and my goals." (P3) "The practices we did make me realize things I knew but did not pay much attention to." (P8)
Time to analyze yourself	9	I became aware of myself, that is, I feed off what they (other students in the group) said and what we did together." (P4) "After the study, I looked back at myself to see how I could work and express myself better." (P10) "I found the opportunity to analyse myself better." (P7)
Good timing in the studio process	9	"I think the timing was very good. After the midterm, everyone was devastated, some of the friends who expected high grades got low grades. This study helped us to recover ourselves after the midterm." (P2) "It was very good timing. Since it was on Tuesday mornings, it was really motivating me before the studio hours. Even if I had only one hour until the studio started, it made me want to do something [study for the project]. So, I was sitting and doing something for my project, saying 'What do I have to lose?'." (P10)
"I am not alone"	8	"When everyone talked about themselves, I realized that we are all alike." (P11) "I noticed people in the same situation as me. I felt that I was not alone." (P4) "It was nice to have the environment of those who experienced the same situation. I wasn't alone. It felt good to know that there are people who can tell and understand what I went through." (P9)
Comfortable environment	7	"At first, I wasn't sure if I would attend, but when you said that there are motivational techniques and that I could learn them, the event caught my attention. Also, since we could share our thoughts, it was like a therapy session." (P3) "The working environment was a more comfortable and freer environment, unlike our studios. That's why I was able to express myself." (P7)
Earlier need in university life	7	"I wish this study was in the previous year. The second year of my university was a complete mess. The worst period of my life. My most hated period. If only it was then, it would have been a less bad semester for me." (P2) "It might be even better for freshmen. After making a few mistakes, they can reflect on themselves and say 'Where have I made the mistake?'. The sooner the better." (P9)

Table 8 Students' views on the activities practiced in the intervention

Categories	*f*	Student expressions
Setting and achieving goals	11	"I wanted to learn software-related coding. I watched tutorials on Udemy. Because the project was bad anyway, I planned to focus on my other goals. I thought I could improve myself in the field I want." (P1) "I know that my product (design) is not super great in my project, but I researched everything I put in my project. I decided on this approach after the goal planning activity where you made us set goals. I planned as my goal that I will think in detail about every decision and move I make. I'm going to put something in my project, how can I put it, what is this in real life, and so on. I felt so good knowing that if you break a dryer, I can fix it again. I've been working on it a lot. But I know I wouldn't have done this without the intervention study." (P2) "I was away from the rhino [computer-aided 3d drawing software] at the beginning. Then I set to study on rhino as a goal for my project, and when I did it, I liked it, I remembered, I continued, I even tried different renders, etc. In that sense, I felt that I improved myself a little more, rather than designing for a company or a studio. I started to trust my project more. I realized that I could speak more freely. I was able to present more comfortably in this term." (P4) "I set a goal to find out how the heating and turning functions work together. This gave me the determination to solve. In my previous projects, I did not set my own goal as much as this one." (P6)
Most useful activity: miro	9	"The most useful part is the one with the chart in Miro. I used it to phase my project process in steps. I have used it on my personal plans, too. I'm still using it." (P3) "The applications in the Miro definitely worked a lot. The parts we commented on together at the same time were very useful. I realized that the difficulties I was challenged with were not special to me." (P4) "Especially the post-it works in Miro stuck in my mind. Sometimes I was thinking about how much I had done. After the final jury, I thought how many of my goals in the post-its I have completed." (P7)
Project analysis/replaying midterm records	8	"It was the most helpful activity. It was good to understand what I should concentrate on. Listening to the comments again was good feedback for me." (P6) "We had never done this before. This was the first time. When the midterm jury finished, we forgot everything about it. We celebrated that we somehow progressed, another big assignment is finished, as if we passed the exam. I didn't care about the critics I got. But in this study, it was very useful to watch it again. Later, I watched it 2–3 times more." (P7)

Table 8 (continued)

Categories	*f*	Student expressions
Project analysis/rereading the brief	6	"Before, I never reread the briefs. Now I am reading the briefs." (P11) "I read it at first, but I did not read it again. Actually, it was helpful to understand the expectations of the course." (P5) "It was extremely useful for me. I never read the brief. I don't even look at what I do first. I always look ahead. I like to watch movies a lot, and I knew that in my second watch I perceive something different before then. I did not realize that I did not apply this approach outside of the cinema. I didn't apply it to the brief reading. I realized that in the second read of the brief I can perceive something else. Now, I'm trying to interpret the brief differently in every read." (P10)

Table 9 Students' Comments on Themselves After the Intervention

Categories	*f*	Student expressions
Strategy development	9	"I started to work with watercolor. I'm planning to start to work with my iPad now. I was studying by writing the same notes over and over for exams, I never understand by reading. But I understood that it was too much work. I've tried to get over this, and finally this semester I achieved a first in my 15 years of education life. I managed to change my way of studying. It was a starting point for me." (P2) "I focused on my process in the project, and I think it was not a bad decision. I tried to have something to show every week because I think the process was given more importance. Most of the percentage of evaluation included the process, the rate was almost the same as a jury." (P3) "I realized that I like to take notes and write with nice pens. I realized that when I write with beautiful pens, I am more encouraged to do it. That's why I'm trying to work with paper now." (P5) "I never thought before that [intervention] what I should do for the better. But what we did in the study affected me, [showing] that instead of trying to learn something without liking it, I will try to make it interesting." (P7)
Increase in self-confidence	8	"During this period, I realized that I know what to do. This study gave me the first step to try." (P11) "I became aware of myself. I can dare and trust my project. This study showed me that I need to be confident in myself. To be honest, I used to study to get good grades. This year, I approached [my work] boldly. I persisted on what I was doing. In the past, when I thought I couldn't do it and that people were doing better than me, I always pulled away. But now I start to think that I do things better than some other people." (P4) "I think if I can continue what we tried during the study, I will increase my self-confidence even more. Because normally, I would pull away from myself with the smallest negativity. But this semester, I felt self-confident, I think that I did what I really wanted to do in my project." (P6) "My project was the best project of the entire studio. I'm satisfied with everything I did. What I received (grade) was not satisfying, but I stand behind my product. I generally don't feel comfortable with my projects, I always find something to criticize. But I feel very satisfied with this project." (P10)

Table 9 (continued)

Categories	*f*	Student expressions
Learning orientation	8	"Before, when the brief arrived, we tried to do whatever is requested. Our aim was always to satisfy the teacher to get good grades. When they commented on our works in different ways, we got lost. The reason for that was being focused on what the teachers wanted to get high grades. This year, after our sessions, I felt this emptiness about myself, I realized how nice it is to do projects for myself, not for them. I also found what I want to do in my graduation project. It was definitely the studio I enjoyed the most in my life." (P2) "In fact, I got a better grade than my previous projects, but I had aimed for a much better grade this term, but I couldn't [get that]. But I am happy with my process because I had a very productive process for myself. I think that what I learned is more than my grade." (P8) "I ask myself whether I did something I felt good about or not. I liked the last product I designed for my project very much. Maybe I didn't get a good response as a grade, but it made me make some decisions about myself." (P6)
Influenced by the sample/peer	6	"In one of our sessions, you [the researcher of this thesis] gave an example about your experience with finding your drawing style. If you look at my process, the styles of my drawing changed completely after that week. Even though it took more time, including watercolor while using markers for drawing helped me to start studying beforehand. From now on, I want to develop it [further]." (P9) "From the moment you explained that this [your learning method and strategies] can be learned, the event caught my attention." (P3) "You told us about your experience of finding your drawing style in a session. After that, I criticized myself to see how I could work and express myself better. I realized that I stopped taking notes which were one of my favorite things, colored pencils, writing with images, etc. After that speech, I bought a new notebook for the project and spent the semester with it." (P4)
Continuity	5	Then I used our page on Miro again. Now this semester, I will prepare a page for myself. With the help of this study [the intervention], I learned how to do it [planning to study]. I know how to study much better now." (P2) "Watching midterm jury records were very useful. I watched it 2–3 more times after that. I will record and watch or listen to my presentations again from now on." (P7)

unmotivated in the studio process. Seven students also indicated that an intervention study would be helpful in the first or second year of university because of the new learning environment and the intensity of the uncertain processes in the studio.

Students' Views on the Activities

Students were asked about their opinions on the intervention activities in detail. As shown in Table 8, their responses were classified into four main categories.

In the interviews, all students praised the goal planning activity and stated that they achieved their project goals. It was observed that this activity improved students' self-efficacy by directing attention from grades to learning. Students also worked in groups and individually on Miro to identify and plan for challenges in their projects. Nine students noted that in the group activity, everyone had similar difficulties and this gave them comfort during self-evaluation. They said that having their goals on post-its helped them remember and track their progress. Also, students said the Miro activity was the most beneficial in the study. The reasons for this may include Miro's easy interface process and students' familiarity with it (e.g., they could use it interactively and open private pages to review their work).

Students' interpretations of the project analysis activities indicated that all students had not re-read the project brief after the first studio day. Re-reading the brief revealed new meanings to them. The students were initially embarrassed and refused to watch their mid-term jury recordings since they did not like watching themselves. They agreed to participate after being encouraged to focus on content rather than visuals. They watched in separate Zoom rooms and were pleased to recognize their areas of weaknesses (e.g., could not convey what they wanted to say, saying things that the jury would misunderstand, omitting important project details, etc.).

Students' Comments on Themselves

After the intervention, students were asked about their self-assessment. As shown in Table 9, the students' perceptions of their advancement were classified into five main categories.

Students were encouraged to devise strategies that would help them achieve their study goals. As evidenced by their remarks, students found new methods to express themselves and created process-oriented strategies. They were more focused on themselves than on their grades. Learning about their abilities and desires strengthened their self-efficacy. Eight of them utilized self-confidence and self-discovery terms frequently. These outcomes were attributed to a learning-focused development strategy.

During the intervention sessions, the researcher shared their own experiences of identifying a learning strategy, such as discovering their sketching style. Six students reported that they were motivated to take action to identify their strategies. In addition, five students said they would employ some of the activities in the next semester. This was an important indicator of SRL skills since task perseverance is an outcome of self-efficacy and self-regulation (Schraw, 2006; Zimmerman et al., 1992).

The Integrated Analysis

To evaluate the effect of the intervention on the use of the SRL strategy, two types of data were collected and analyzed together for a deeper understanding of the intervention.

A joint comparison matrix was used to determine the agreement levels between the data sets (Creswell & Plano Clark, 2018; O'Cathain et al., 2010). Table 10 presents the coherence of the findings. Improvements in some SRL strategies were prominent in both data sets—planning, seeking appropriate information, self-monitoring, self-evaluation, and self-efficacy significantly increased, statistically, post-intervention. Qualitative data provided explicit descriptions of these strategies. The findings also included some contradictions. Qualitative findings revealed modest improvements in seeking assistance, goal orientation, and task value although no statistically significant increases were revealed in the quantitative analysis of the data. This enabled to interpret unanticipated quantitative results qualitatively.

Table 10 Joint comparison matrix

SRL strategies and motivational factors	Quantitative (SSRL pre-post test results)	Qualitative (content analysis of interview)	Agreement, partial agreement, dissonance/expansion, no match
Arrangement of study time	–		No match
Planning	+ +	+ +	Agreement
Environmental structuring	–		No match
Organizing and transforming	–		No match
Seeking appropriate information	+ +	+ +	Agreement
Seeking easily accessible information	–		No match
Rehearsing and memorizing	–		No match
Self-monitoring	+ +	+ +	Agreement
Seeking peer, teacher, or adult assistance	–	+	Dissonance/expansion
Self-evaluation	+ +	+ +	Agreement
Self-consequences after success	+ +		No match
Self-consequences after failure	–		No match
Self-efficacy	+ +	+ +	Agreement
Goal orientations	–	+	Dissonance/expansion
Task value	–	+	Dissonance/expansion
Attributions for failure	–		No match
Anxiety	–		No match

+ +: exact information related to a finding

+: supporting/related information related to a finding

–: contrasting information related to a finding

No symbol: no information

Discussion

In this experimental study, I evaluated a self-regulation intervention in an ID studio. The aim was to understand the effect of self-regulated intervention in studio on design students' (1) use of SRL strategies and (2) design performance. Concerning the first aim, convergent mixed methods were employed. The integrated analysis indicated that design students who engaged with the intervention demonstrated increases in metacognitive strategies (e.g., goal planning, self-monitoring, and self-evaluation); motivation level (e.g., self-efficacy), and behavioral strategies (e.g., seeking information and help). Concerning the second aim, students' jury grades were tracked and compared within and across groups. The comparison analysis revealed that design students who participated in the intervention received higher jury grades than the students who did not participate. The following paragraphs discuss the changes in strategies and design performance.

Change In Metacognitive Strategies

Metacognitive strategies help students to monitor themselves. These strategies teach students to plan goals, activate prior knowledge, and prepare the materials according to their learning style (Pintrich, 1999). In collaborative learning environments (e.g., design studio), metacognition has a central role in supporting individual and group regulations (Järvelä et al., 2021). Goal setting is one of the fundamental metacognitive features of self-regulation (Boekaerts & Niemivirta, 2000). During the intervention, students were encouraged to define and plan for their personal project goals. This approach was intended to help students reflect on their learning processes and strategies. The integrated analysis demonstrated that *goal-setting activities* supported the development of SRL skills. Participating students managed to set future process and learning-oriented goals. Two participants expressed their willingness to set goals for other courses and also their social life. Another student proudly mentioned the accomplishment of her goals. Yet another student stated that he still followed his off-project goals (e.g., doing sport regularly) that he set during the intervention. These findings support the notion that planning goals and monitoring them throughout learning can increase learning efficiency (van den Hurk, 2006).

Design students are exposed to emotional triggers because they require constant feedback and approval to continue developing ideas, which is a sensitive process (Goldschmidt et al., 2010). Some students can be overly invested in the instructor's negative or favorable comments, which hinders the learning process (Kavousi et al., 2020). These students need a reference to assess and interpret criticism with their ideas and aims. Goals are like safety jackets for students. They can help reduce external dependency and syncretize comments with their own goals. When actively participating in SRL activities, design students were more likely to use effective learning strategies, set goals, customize goals as per their preferences, track their progress, and evaluate themselves using the tools offered. Also, metacognitive strategies scores increased as per the quantitative analysis. Such improvements in both data sets show that students' use of metacognitive strategies changed positively after the intervention.

The integrated findings indicated an increase in the use of *self-monitoring strategie*s. Students reported using new notebooks and/or pens to take notes on their design process. They also watched themselves (i.e., self-watching)) on their jury presentation recordings, an example of a self-monitoring method. Students stated that they would use video or voice

recording in future studios. Thus, learning self-monitoring skills is beneficial for students (Chang, 2007). While self-monitoring is required for self-regulation, it is not sufficient (Schunk, 1995), because self-monitoring is influenced by both individual processes and behavioral factors (Zimmerman, 1989). Self-monitoring strategies like self-trial and self-recording require systematic and frequent tracking (Bandura, 1986). Design involves long and complicated cognitive processes during which ideas and/or comments can be forgotten. Therefore, self-monitoring demands this type of tracking method. Self-monitoring strategies would help design students track their progress and reflect on their ideas and comments, thus providing the necessary materials to self-evaluate. Schunk (1995) suggests that explicit self-monitoring of skill acquisition through self-evaluation of capabilities improves student achievements. For a productive learning environment in a design studio, these two self-regulation skills—self-monitoring and self-evaluation—should be linked to student goals.

During the intervention, a micro-teaching method from the education literature was employed to create an environment for *self-evaluation*. Students watched their mid-term jury recordings and evaluated their projects and presentations using the jury requirements. They reported hypothetical concerns before watching themselves and stated that self-watching helped them identify their weaknesses and mistakes and ponder necessary improvements. Thus, students were able to plan their goals more effectively because they were aware of their future needs. Some students talked about their plans to develop their knowledge base, which they thought inadequate (e.g., sketching, computer-base drawing, design history). Students were able to concentrate on the process since the mid-term jury was not the final assessment. They could embrace their weaknesses and strengths and become more learning-oriented through discussion on individual differences. These findings support the notion that observing self-performance enables one to monitor SRL behaviors and self-learning processes in a real-world and dynamic social setting (Kohen & Kramarski, 2012).

A critical instructional perspective creates an environment of rich externalizations and interaction for learner experience. In this environment, students can develop their value-driven design expertise and design identity (Gray et al., 2020)). Both the design process and design education should include the designer's self-processes. In the design studio, instructors' criticism is the key evaluation method, while students' remarks are rarely heard. According to Chien et al. (2021), self-evaluation improves ID students' self-efficacy. Our study revealed that self-criticisms enabled by micro-teaching help students understand their values and develop their learning identity. Finally, self-evaluation behavior increases students' self-efficacy, indicating that motivation is an essential component of the SRL cycle (Zimmerman, 2000).

Change in Motivational Level

During the intervention, participants were encouraged to compare their performance with the success criteria of the design studio. This increased students' self-efficacy and persistence (Zimmerman, 2000), which guarded against the adverse effects of harsh criticism. Self-belief and its challenges in the design studio are discussed by Ochsner (2000) from a psychoanalytic perspective:

> Many students are motivated to apply to architecture school by an idealism about the environment and a wish to contribute to human betterment. Some are also clearly

> motivated by the kind of experience they will find in a design studio—they are seeking a place where they can draw on ways of being and thinking that they sense are possible, but they have not found widely understood or recognized. They may not be able to articulate this consciously, but many are seeking to recover aspects of the transitional space of creative play lost since childhood. To do this requires a suspension of disbelief and an acceptance of the process before the results can be assured. For students, this can be exhilarating, but the uncertainties and ambiguities can also be frightening (*p*.203).

As this quote shows, design students need to develop their self-belief to capture and use their creative side. However, this can be frustrating due to the complexity of design studios. Design students who lack self-efficacy may underperform even if they are skilled designers (Powers, 2006). The role of design instructors should also include developing students' self-efficacy. Self-efficacy beliefs are shaped by earlier self-experiences but can also be influenced by the experience of others, verbal convincing, and the learner's physiological reactions (Bandura, 1986; Bong & Skaalvik, 2003; Pajares & Valiante, 2002, as cited in DiFrancesca et al., 2016). During the intervention, sharing personal experiences prompted students to relate to their own experiences. The qualitative analysis revealed that design students were more likely to share positive or negative experiences with peers when the environment was supportive because it helped them to feel less lonely and increased their self-efficacy. The quantitative analysis also revealed an increase in students' self-efficacy scores. Both data sets provide evidence of the strengthening of students' motivation levels.

Teacher training studies (Dermitzaki & Kriekouki, 2017; Liu, 2016), found that experience sharing could be a potential SRL training method for students. Powers (2006) states that low-achieving design students are less likely to utilize goals to connect with peers, as a result of which they interact less with their peers as they deliberate on their studio performance. To better interact with peers, students should be encouraged to share positive or negative experiences. By reflecting on similar stories, they may overcome their frustrations as they struggle to improve their skills.

Change in Behavioral Strategies

Seeking information is a process of selecting the most suitable information sources (Uçak, 1997). Due to the rapid evolution of technology, the ability to quickly and efficiently access information has become a requirement of the modern era (Oz, 2019). The self-regulated learner is expected to gather and organize appropriate information. During the intervention, students were encouraged to think about relevant information sources for their personal project goals. Searching for information to inspire rather than imitate was emphasized. Both qualitative and quantitative findings showed that when students advanced in learning goals, they sought out more learning-oriented information. Students were willing to thoroughly research their topics and align their findings with their goals and project requirements.

In a design studio, students begin by developing ideas and conducting ongoing research. This can be difficult for underachieving students with limited and/or negative experiences. These students encounter two challenges while collecting information to address ill-defined design problems. Specifically, they have trouble defining the problem and knowing where to begin (Rittel & Webber, 1984). According to Powers (2006), low achievers prefer the trial-and-error method using first online information they reach since they have less ownership of their project and focus on grade rather than learning. Guiding low-performing students

to understand the importance of goals and develop their self-efficacy helps them to engage with external resources. Chen (2016) discovered that while senior design students use external resources such as objects (e.g., internet, books, magazines, products), strategies (e.g., brainstorming, discussion, observation, interview, survey, practice, computer-aid), and their local amenities (e.g., library, workshop, processing factory, department store) to address learning problems, junior design students rely more on human resource (e.g., instructors, peers, technicians, experts, family, friend). A scaffolding approach in which, instructors can direct students to use information as a tool, not a goal, would be useful for students of all levels.

Seeking help is the ability to use peers, teachers, or other adults as resources to deal with learning uncertainties and difficulties (Newman, 2008). Unlike other self-regulated strategies, help-seeking requires social interaction. During the intervention, the main topics included being open to criticism, sharing opinions, integrating opinions with individual preferences, and connecting every project detail to learning goals. According to students' statements, they were conscious of their need for assistance and preferred to consult senior peers. This finding is per Karabenick and Knapp (1988) who suggest that students may be ashamed to ask questions because of emotional pressure in the studio and prefer to hear feedback from peers outside the studio. Both reasons indicated a need for more focused and flexible communication in the studio. The "mystery-mastery" syndrome which was defined as the inaccessibility of the instructors in the studio by Schön (1987) may cause low achievers to feel out of place and prevent them from asking for help. Notably, in a design studio where collaboration is expected, underachieving students displace themselves by refusing to communicate.

Sungur and Yerdelen (2011) attributed underperformers' poor usage of help-seeking strategies to the exam-driven educational system in Turkey. Due to national prescriptive tests for gaining admission to good high schools and universities, students' competitive behavior begins in middle school (Sungur & Yerdelen, 2011). Accordingly, when students encounter a studio that combines individual and collective procedures, they need to adapt their learning practices. Schön (1985) states that the design studio's purpose is built on teaching the language of design and designing. However, due to its complex instructional structure, this new language is not easily explained or transferred to novices. If poor performers cannot receive adequate explanations from studio instructors, they turn to their peers for assistance. Help-seeking can be stigmatizing due to its implications of inadequacy, resulting in personal consequences like feeling obligated to compensate the helper (Karabenick & Gonida, 2018). Therefore, underperformers are reluctant to ask for further assistance. This impediment to help-seeking should be removed by clear communication on studio education.

During the intervention, students expressed their feelings of loneliness while working in the studio. Although scale scores did not support this outcome, the qualitative findings indicated that students felt less alone after talking about their struggles with their peers and were able to express their thoughts about their processes more easily. This conclusion is consistent with Bilgin and Akkapulu's (2007) findings that peer attachment reduces loneliness and promotes social self-efficacy in adolescents. Sherer et al. (1982) define social self-efficacy as one dimension of self-efficacy and confidence in self-social skills. The design studio requires high social skills students who can present their work with panache to instructors, guests, and peers. Dunbar et al. (2018) found that collaborative learning environments promote social self-efficacy, which in turn promotes academic performance. Peer interaction in the design studio contributes to a collaborative learning structure (Wang, 2010) so that students become proactive, self-regulating learners (Crolla et al., 2019).

Change in Design Performance

Before and after the intervention, the grades of all students were tracked and then compared vis-a-vis their groups (i.e., the grades of the students in the experimental group were compared with the grades of the students in the control group). The comparison analysis for each evaluation criterion of the jury indicated that the students in the experimental group had higher grades than the students in the control group following the intervention even though there was no statistical difference between the groups before the intervention. Participants' grades improved following the intervention, indicating a positive relationship between SRL strategies and design achievement. Our results support the positive correlation between SRL and academic achievement (Araz & Sungur, 2007; DiFrancesca et al., 2016; Erdogan & Senemoglu, 2016; Loeffler et al., 2019; Zimmerman, 1990).

Rubenstein et al. (2018) highlight the challenges of evaluating creative processes given their psychological and social patterns and intentional actions. Nevertheless, they suggest SRL measurement methods to assess students' creative processes. Studies in art and design education have also shown a strong relationship between SRL techniques and creative performance (Greene et al., 2019; Hargrove, 2007, 2013; Sawyer, 2017). However, it should be noted that my study did not focus solely on the creativity of students' final projects. Instead, I centered on academic design performance, which included creative performance as a criterion. Higher education generally assigns *higher-order* abilities to creativity, and evaluation typically mirrors that in practice with an emphasis on the outcome and the *craft skills* of implementation (Cowdroy & de Graaff, 2005). Academic design performance is assessed differently from creative (i.e. professional) design performance. Buchanan (1998) characterizes design education as a distinct field that complements, but does not duplicate, professional practice. Thus, the emphasis of design studio evaluation should not be only on the creative output, but also on the learning process that underpins it. Design instructors evaluate not only the creativity of the final project but also the idea's continuity, timing, and development throughout the design learning process. This study on learning in the design studio provides a vital starting point for discussion and further research on design performance with SRL strategies.

Limitations

The intervention study was participated by 11 junior ID undergraduates on a voluntary basis within a studio course at Istanbul Bilgi University that had its own instructional goals and processes. Even though this study verifies previous findings, brings light to new ones and signifies relationships from the data, we acknowledged that there were limitations. The size of the sample group presented limitation regarding external validity in terms of generalizability to other subjects, settings, or time. On the other hand, no unanticipated challenge emerged during the study due to the size of the sample. Mixed method research design was utilized and data was collected through both quantitative and qualitative methods to minimize the limitations. More than collecting one type of data provided to make more accurate interpretations as pointed out by Creswell (2014). Besides, the inter-coder reliability for qualitative findings was 83%, which also indicates a good level of consistency of data code groups.

This study attempted to establish a foundation for understanding the SRL process in terms of the ID studio rather than drawing generalizations and making meta-analysis for design education. The sample held information relevant for the aim of the study, sample specificity was acceptable and was appropriate for the analysis strategy. Finally, the results drawn out were supporting the inital hypothesis. The findings are promising with regard to the establised theories, yet a larger representative sample size is needed to generalize across design sub-disciplines, settings, and education levels.

Conclusion

In this study, I aimed to better understand the design learning process and provide insights for redesigning the studio learning experience through the application of SRL strategies. The social-cognitive view of SRL allowed the researcher to develop and apply a domain-specific introductory-level SRL intervention in the design studio, which opened new communication channels for design students. The findings illustrate that activities for promoting SRL in design studios can assist design students to improve their design learning experience and performance. Both theoretical and practical implications can be drawn from the findings. This section summarizes some pedagogical insights for design education derived from this study.

Florishing Personal Goals

High dependency on external factors has a detrimental effect on design process. Personal goals provide students with a reference point to interpret the design feedbacks. Encouraging and orienting personal goals address the internal characteristics of the design students (e.g., their judgment, perception, appreciation, empathy, courage, imagination), which is also suggested for design studio education by Buchanan et al. (2013). Metacognitive activities such as goal planing provide proper content for students' individualistic features to discuss with them. The aims of the project and the goals of the students should be differentiated and then syncretized together through the conversations in the studio. By doing this, students can comprehend the importance of their own goal plans and orient them towards learning. Personal taste and attitudes of the students can flourish through such an approach which also helps to increase their self-efficacy and decreases the high external dependency.

Watching Self-Recordings

Due to its complex longitudinal process, the most frequent problem of designing is forgetting or misunderstanding the ideas and/or comments on one's design. Design learners need methods and tools to trace their designing process. Design instructors should encourage students to record their own process via either digital (video, audio recording) or physical (note-taking, drawing) tools. Since the student's emotional experience is higher while presenting or explaining their work, this recording activity should include especially critic sessions and jury presentations. For underperforming students, note-taking can be frustrating since they do not count on their abilities enough. Therefore, especially these students should be presented with easy recording methods such as audio or video records. However, recording is not a satisfactory learning strategy without reviewing. Specific time allocations should be included in the studio process for evaluating these records. These sessions

can be conducted within student groups or individually. However in both, the instructor should be included in the process to lead the students in self-evaluation. Having a metacognitive view through self-evaluation encourages low performer design students to regulate their learning strategies, develop self-belief, and explore their ways of designing which is the main purpose of studio education.

Questioning the Studio

In self-regulation, outcomes of the learning activities feed the other strategic learning steps. While metacognitive strategies such as planning goals, monitoring, and evaluating help to increase the self-efficacy and motivation of the learners, they also give students a point of view to regulate their behavioral strategies. Help-seeking as a behavioral strategy is the only strategy that requires social interaction in SRL. Design students may have problems reaching the studio instructors for asking for help when they are insecure about their process. They are mostly afraid of being criticized and consequently demoralized or feel too embarrassed to ask questions. The educational system that they were previously part of was based on a competitive approach, so they need to adapt to the features of the collaborative learning environment. In some cases, reflective conversations with the instructors are not enough to make students understand the learning process. They need more explicit and flexible communication in the studio. Questioning the studio at a meta-level can be helpful to develop more sincere dialogues between instructors and students, which also helps to create a more collaborative environment. In these meta-studio activities, students should be encouraged to compare the criteria of success and their performance in the design studio explicitly, so that they can define their weaknesses and strengths. This activity also allows students to question the decision-makers of the studio and decrease their high dependency on them. Critical thinking requires questioning minds so that all kinds of information can be synthesized. The fewer the number of external factors that students depend on, the more agency and awareness they can develop.

Sharing Experiences

In the design studio, knowledge is constructed mostly through reflective conversations between the instructor and the student. These conversations vary according to the works and activities of the students. In the case of no development in the project or no activity during the week, the effectiveness of the critic session decreases. Instructors may not look for the reasons for these situations, and they might simply assume that students are not investing enough time in their studies. Instead, instructors should pay attention to the motivational factors which have a big effect on the learning process. Even though students try to apply learning strategies, motivational deficiency can cause them to underperform. Experience sharing is a motivational strategy that can be promoted through group tasks or activities in the studio process. Design instructors can share their experiences of learning and designing to encourage students to share their difficulties and problems with their peers as well. This creates another level of communication for these students and increases social self-efficacy by empowering them via making them feel less alone in this journey. Higher self-efficacy helps the students to trust their abilities and regulate their learning strategies accordingly.

The design domain in SRL studies is under-researched globally and has not been studied in Turkey. To the best of our knowledge, this study is known to be the first to examine SRL

strategies quantitatively and qualitatively through SRL intervention in an industrial design studio. This study fills a gap within the existing body of design pedagogy and instruction in industrial design relative to self-regulated learning. It highlights the importance of students' self-awareness, learning strategy preferences, and motivational aspects in the studio education process. Design studios will not fulfill their potential to foster SRL skills through the signature pedagogy unless individual student differences are paid attention to. Studio education needs improvement to encourage students to develop their learning skills. The implementation of SRL strategies in design learning environments can help to improve the design performance, especially, of less accomplished students. More empirical studies are required to verify and enhance design education. Our study will hopefully serve as a base and starting point for discussion and further research.

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Declarations

Conflict of interest The author has no competing interests to declare that are relevant to the content of this article.

Ethical approcal This study was based on author's PhD dissertation titled "Developing student performance in industrial design studios through self-regulated learning strategies", Istanbul Technical University, Graduate School. The author immensely grateful to Prof. Dr. Gülname Turan, the thesis advisor, for her valuable critics, guidance and encouragement. The study was conducted in accordance with the ethical principles for research involving human subjects and ethical approval was provided by the University Ethical Committee.

Informed consent All participants provided informed consent.

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