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Differences in self-regulated learning strategies among industrial design students: A convergent mixed-methods study

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Abstract
The value of self-regulated learning skills for academic achievement has been shown in different domains. However, self-regulated learning skills in design studio education have rarely been studied directly. This study aimed to explore differences in self-regulated learning strategies and motivational factors between high and low achieving industrial design students in an industrial design studio course. We applied a convergent mixed methods design with self-report questionnaires and interviews to gain a comprehensive understanding of students' strategy use. The integrated analysis of quantitative data from 47 students and qualitative data from 16 students demonstrated differences between high and low achieving design students' self-regulated learning skills concerning the use of metacognitive, motivational and behavioral strategies. Together with the expanded integration of data analysis, these findings indicate that self-regulated learning examinations should be undertaken with caution in design studio contexts.

Keywords
Design pedagogy, Individual difference, Industrial design, Self-regulated learning, Studio education.

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1. Introduction

The perpetual changes in the world require individuals with deep knowledge and skills to navigate the economy and society. Twenty-first-century competencies defined by organizations such as the Organisation for Economic Co-operation and Development (OECD), World Economic Forum and the United Nations Educational, Scientific and Cultural Organization (UNESCO) concur regarding the need for agency, awareness and ability of learners to deal with complex problems (see Rieckmann, 2018; Schleicher, 2018; World Economic Forum, 2020). Providing learners with these skills is important at all education levels. Industrial design (ID) studios in universities can facilitate these abilities as they provide students with essential skills and experiences to cope with complex real-world problems that are accepted as key characteristics of design practice. Along with the changing target competencies, self-regulated learning (SRL) – representing metacognitive, motivational and behavioral strategies – has attracted much attention in the last four decades due to its contribution to academic skills (Zimmerman, 1989b, 2008). These academic skills promote future competencies related to learning strategies. While some studies indicate that studio education fosters SRL skills (e.g., Greene et al., 2019), SRL strategies in ID studios and individual differences in SRL among design students remain under-studied. This research explores the differences in SRL strategies between high and low achieving students in an ID studio course. The study aims to understand the differences between ID studio students and define the dynamics of SRL in the design studio to improve design studio education.

1.1. Self-regulated learning

The social cognitive theory defines self-regulation as interaction within personal, behavioral and environmental factors (Bandura, 1986; Zimmerman, 1989a, 2000). In learning environments, the changes in these factors necessitate the regulation of the learner (Zimmerman, 1989a; Zimmerman & Cleary, 2009). Self-regulated learners can define personal goals; choose, develop and perform appropriate strategies; monitor their process and regulate according to outcomes with a belief of self-efficacy (Nilson, 2013; Zimmerman & Schunk, 2011). There is vast evidence that SRL strategies help students accomplish their academic goals (Sungur & Yerdelen, 2011; see also Zimmerman, 2000; Zimmerman & Schunk, 2011). However, even in tertiary education, most students do not know how to learn (Nilson, 2013). Students at this level may have difficulties making strategic choices that prevent them from achieving, especially in their professional lives (Sakız, 2014). Thus, the goal of higher education should involve providing academic and professional knowledge and teaching effective learning strategies to create life-long learners (Tas & Sungur, 2012; Zimmerman, 2002).

Multiple SRL models have been proposed based on theoretical perspectives. A common feature of these models is that students use different activities, skills or strategies to control and regulate their learning (Jansen et al., 2019; Dale H. Schunk & Zimmerman, 1994; Zimmerman & Schunk, 2011). Zimmerman's SRL perspective (see Zimmerman, 1989a, 1990) which has been used more frequently because of its specific subprocesses (Panadero, 2017) defines self-regulated learners as individuals who actively engage in and manage their learning through metacognitive, motivational and behavioral activities (Zimmerman, 1989b, 2002, 2008). In terms of metacognitive processes, self-regulated students plan their learning process, determine goals, monitor, evaluate and reflect on their cognitive strategies (Dinsmore et al., 2008; Veenman, 2017). They have a high level of self-efficacy, i.e., belief in the ability to complete a task successfully. As motivational processes, they are intrinsically interested in tasks and responsible for their achievement outcomes (Zimmerman, 2008). For behavioral processes, they seek information and help, and structure learning environments (Sebesta & Speth, 2017; Zimmerman & Martinez-Pons, 1986, 1990). This study refers to these three strategy categories of Zimmerman's model to explore the SRL dynamics in design studio (see Table 1).

SRL skills are teachable (Panadero & Alonso-Tapia, 2014). However, as some students already have these skills (Nilson, 2013), defining and assessing the level of existing strategy use is an important first step. Self-report (i.e., questionnaires, interviews, think-aloud and learning diaries) has become the most common method for identifying and evaluating SRL strategies (see Azevedo et al., 2009; Kavousi et al., 2019; Kryshko et al., 2020; Loeffler et al., 2019; Räisänen et al., 2016). Although these measures do not track real-time performance and are prone to recall distortions (Veenman, 2017), they play a crucial role in reporting psychological processes in SRL (Pekrun, 2020). However, using one single tool has been criticized because of its inherent weakness in capturing the learning strategies (Perry, 2002). Clearly et al. (2012) highlight multifaceted evaluation as the most useful method for increasing self-regulation strategies knowledge (e.g., Baldan Babayigit & Guven, 2020; Coertjens et al., 2016; Foerst et al., 2017; Hendriks et al., 2020; Jansen et al., 2020; Pekrun et al., 2002; van Laer & Elen, 2020). Mixed methods approach offers advantages for SRL studies in compensating for missing data and confirming overlapping data (see Plano Clark, 2019). This study aimed to identify design students' SRL strategy use, taking advantage of both questionnaires and interviews as mixed methods. The first author also observed students for an entire semester – in the studio coordination team participating in all classes and this was hypothesized to provide more reliable estimates of strategy use.

To better understand the complex relationship between SRL strategies and academic achievement, students' strategy use must be compared relative to their achievement levels. Research has compared high and low achievers' attitudes and characteristics, attended various education and learning environments (e.g., Coertjens et al., 2016; DiFrancesca et al., 2016; Erdogan, 2011; Fadlelmula et al., 2015; García-Pérez et al., 2020; Geduld, 2016; Khan et al., 2020; T.-H. Lee et al., 2010; Nandagopal & Ericsson, 2012; Sungur & Yerdelen, 2011). Very few empirical studies have focused on SRL in design studios (e.g., Oluwatayo et al., 2015; Powers & Miller, 2008). Despite different domains and tools, the general results of these studies were similar, i.e., SRL positively affects academic achievement. However, few descriptive studies demonstrated that SRL strategies are nuanced, depending on the specific event (Nandagopal & Ericsson, 2012). Greene et al. (2015) found that advanced cognitive strategies varied according to discipline. The detection of these domain-specific differences remains a gap in the literature (Alexander et al., 2011; Greene et al., 2015). Thus, this study used qualitative interviewing methods to explore students' perspectives regarding domain-specific learning strategies, attempting to align with the quantitative approach to develop a primary perspective on individual differences, especially for low achieving design students.

1.2. Industrial design studio education and self-regulated learning

University students need to be independent learners with the capacity to plan, monitor and evaluate their work and control motivation and emotion (Vosniadou, 2020). Some professions demand these skills in different approaches, which creates characteristic forms of teaching and learning. Shulman (2005) defines these unique preparations for the professions as 'signature pedagogies.' Design studio education is a signature pedagogy with a distinct pedagogical method (Shreeve, 2015; Shulman, 2005) that includes learner-centeredness, interaction between the actors and the studio environment (Yorgancioglu, 2020).

Industrial design undergraduate education occurs over eight semesters and at least four years. Studio teaching occupies about 30% of the entire curriculum. In design studio, starting with a project brief involving 'ill-defined' (Rittel & Webber, 1973) or 'wicked' (Simon, 1973) problems, students are expected to develop solutions and present them showing weekly progress to discuss with the instructor or peers and guests (Goldschmidt et al., 2010), known as studio critics. Critics

iteratively provide students with a constructive learning process (Tovey, 2015). Conversation between student and instructor centers around the student's work (Schön, 1987). Thus, students are the main actors and fully responsible for constructing self-knowledge. However, this critical and self-constructive process may create challenges for students who struggle to engage with the socio-cultural context. They may not meet the studio expectations and lose their self-confidence (Masatlıoğlu & Takkeci, 2016). They need a 'safe space' to realize and develop their design approach without the fear of failure (Bull, 2015). Studio instructors should encourage skills (e.g., critical thinking, self-reflection, self-regulated learning, perseverance) necessary to address the fluidity of design problems (Smith, 2005).

Learner-centered learning traits can be observed in most forms of design studio education (i.e., architectural, interior, landscape and industrial design). Such approaches include problem-based learning (Boyer & Mitgang, 1996; Galford et al., 2015; Smith, 2010), project-based learning (Bell, 2010; Kuhn, 2001), the alternative student-centered framework described by Lee and Hannafin (2016) in response to criticisms of other studio-oriented/based learning (Cennamo et al., 2011; Kjesrud, 2021; Zairul, 2018). These learning-based studies highlight the essential characteristics of the studio pedagogy, which are about experiencing and understanding the design process (Smith, 2010). Studio education is widely held to place the student in the center with active participation (Powers, 2016), but learner-centered learning tends to be disregarded in studio instruction (Zairul, 2020). In their review study, de la Harpe and Peterson (2009) revealed a greater emphasis on teaching techniques rather than learning techniques in studies of design studios. Therefore, improved scaffolding is needed, considering the learning process of design students.

Design entails a highly organized mental process that manipulates and blends several forms of information into ideas to produce outputs (Lawson, 2005). Cognitive strategies of expert designers' idea-generation process provide some instructional information for studio education (Christiaans, 2002; Cross, 2001; Hasirci & Demirkan, 2007; Haupt, 2015; Kim & Kim, 2015; Newstetter et al., 2001; Oxman, 2001). However, how designers choose and organize these strategies is a metacognitive process that has been unobserved in design cognition (Ball & Christensen, 2019). Based on the limited number of studies (e.g., Ball & Christensen, 2019; Carlson et al., 2020; Hargrove, 2007; Kavousi et al., 2020; Kurt & Kurt, 2017; Tobón et al., 2021) design metacognition appears critical to every aspect of design activity. Nevertheless, design learning is a different process to designing and should be studied with educational theories of learning serving as a foundation for design education (Oxman, 1999). Metacognitive knowledge – as an aspect of SRL – would help novice designers to have a more holistic perspective of learning process, yet important questions about design metacognition remain to be answered.

Studio instructors' pedagogical approach influences student's skill development and self-perception as designers (Yorgancioglu & Tunalı, 2020), and this promotes self-reflection and self-regulation (Greene et al., 2019). However, students' learning approach needs to be aligned with the SRL potential of studio pedagogy. To address this issue, Powers (2016) proposed a methodology within a landscape design studio that incorporates SRL and the process of design learning. In this model, students are actively involved in their learning through SRL, and instructors develop individual objectives for each student. In another study of architecture studio, Zairul (2018) advances a model based on self-regulated theory, which focuses on peer review during studio hours and individual critique beyond studio hours. Despite practical challenges for studio instructors, these studies contain valuable insights for ID studios.

1.3. Current study

Studio education has used a student-centered lens since Schön's (Schön, 1984) concept of the 'reflective practitioner' was incorporated (Iftikhar et al., 2018). To maintain student-centeredness, learner characteristics should also be considered and moni-

tored for personal and social transformation (Thompson, 2020). This creates space for students to acknowledge their agency in shaping their learning process. Hence, we question the claims of the learner-centered and constructivist approach to studio education, shifting the focus to learner autonomy and self-regulation.

While numerous studies have focused on improving specific SRL components, few have examined the differentiation of SRL variables between high and low achieving students in a design studio context. This exploratory study aimed to describe and compare ID students with high and low achievement levels concerning metacognitive, behavioral and motivational SRL factors using both quantitative and qualitative data. This approach may help to understand different learning styles and delineate areas of self-regulation that could be strengthened to support struggling students. Based on these aims, four research questions were formulated:

1. Are there meaningful differences between the SRL skills and motivation of ID students with different academic achievement levels?

2. What are the SRL skills frequently used by ID students with different academic achievement levels?

3. How do high and low achieving ID students perceive their own studio course experiences?

4. To what extent do qualitative and quantitative results converge?

2. Materials and methods

2.1. Participants and procedure

We conducted this study in the Industrial Design Department at a private university. Quantitative data were collected from 47 third-year undergraduate design students (33 females, 14 males). They were on average 21.2 years old (SD = 0.98) and all were in their fifth semester. Qualitative data were collected in a third-year design studio course comprising 16 students (10 females, 6 males) wanting to participate in the study voluntarily. All documents and conversations were in students' native language. The data were stored and transferred using multidigit codes to ensure anonymity. Participants were provided with written information, assured of confidentiality and gave their informed consent to participate. The questionnaire and interviews were administered at the end of the semester so that students could reflect on their current studio projects.

This study focused on third-year design students as, at this level, they have completed at least four semesters of the curriculum, including four design studio courses. Additionally, in the third year, the focus of the studio content moves from a general introductory level controlled by the instructors to an individual development level managed by the students themselves (Uluoğlu, 2000). This more individualized studio context helps students experience more self-process time and allowed us to observe the students in their approach to design.

2.2. Materials

In this study, we followed a convergent mixed-methods procedure (see Creswell & Plano Clark, 2018) undertaking quantitative and qualitative investigation concurrently. We integrated the results through merging analysis and interpreted them to gain a realistic and holistic understanding of students' strategy use.

2.2.1. Quantitative measure: Scale on Self-Regulation in Learning (SSRL)

The self-report questionnaire, 'Scale on Self-Regulation in Learning (SSRL),' was used to determine the relationship between self-regulation and academic achievement of design students. SSRL is a validated self-report scale developed by Erdogan (2012; for the English version see Erdogan & Senemoglu, 2016) to evaluate the SRL skills of [anonymized] university students focusing on their learning habits. The scale consists of two sub-scales: The SRL skills section covers 12 dimensions developed based on Zimmerman and Pons's (see 1986) Self-Regulated Learning Interview Schedule (SRLIS) (Erdogan & Senemoglu, 2016) and the motivational section covers five dimensions (Table 1). The scale has 17 dimensions with 67 items in total and is scored on a five-point Likert scale ranging from 'Never' to 'Always'. According to Erdogan

(2012), the reliability coefficient was calculated as Cronbach Alpha 0.91 for the entire scale showing high internal consistency.

The structure of studio education is different from regular classes. Thus, terms related to class courses in the scale had to be slightly adapted for studio conditions and terminology to enable the students to understand and respond regarding their studio process (e.g., the word 'studio coordinator' was used instead of 'teacher,' and 'jury presentation' instead of 'exam').

The SSRL scale was conducted with hard copy documents, and students were asked to think of how they studied in that studio course. The first author facilitated the questionnaire process with the students and responded to any questions asked.

Table 1. *Sub-scales and factors of the Scale on Self-Regulation in Learning (SSRL) and strategy types used in this study.*

Scale on Self-Regulation in Learning (SSRL) (Erdogan, 2006)	N	Type of strategies used in this study
Self-Regulated Learning Skills		
Arrangement of study time	4	Metacognitive strategies
Planning	5	Metacognitive strategies
Environmental structuring	4	Behavioral strategies
Organizing and transforming	5	Cognitive/Metacognitive strategies
Seeking appropriate information	3	Metacognitive strategies
Seeking easily accessible information	2	Metacognitive strategies
Rehearsing and memorizing	4	Cognitive/Metacognitive strategies
Self-monitoring	2	Behavioral strategies
Seeking peer, teacher or adult assistance	3	Behavioral strategies
Self-evaluation	6	Metacognitive strategies
Self-consequences after success	4	Metacognitive strategies
Self-consequences after failure	3	Metacognitive strategies
Motivational factors		
Self-efficacy	5	Motivational strategies
Goal orientations	3	Motivational strategies
Task value	5	Motivational strategies
Attributions for failure	4	Motivational strategies
Anxiety	5	Motivational strategies

2.2.2. Qualitative measure: Semi-structured interviews

Theory that distinguishes between SRL and ID education is important as SRL and motivation have not been studied structurally for design studio education, the backbone of ID bachelor programs. Qualitative research is an effective tool to understand the relationship between student attributes and the learning environment (Araz & Sungur, 2007) and between SRL and motivation in a design learning context (Powers, 2006). Semi-structured interviews were designed for students to talk deeply about their learning experience in general and in the studio course they had recently completed. The interview questions were developed considering the interview approaches used in other SRL studies (see Coertjens et al., 2016; Kitsantas, 2002; Ley & Young, 1998; Nandagopal & Ericsson, 2012; Powers & Miller, 2008; Sundre & Kitsantas, 2004; Zimmerman & Martinez-Pons, 1986) and rephrased using design terminology. Without asking directly about SRL, it was possible to see how important self-regulation was in their process (Räisänen et al., 2016). Based on the qualitative analysis approach of this study, interviews and their analysis proceeded simultaneously and iteratively. Follow up questions to probe further were formulated as the analysis was undertaken and following interview sessions were organized with the 16 interviewees.

Sixteen third-year ID students were interviewed at the end of the term. Conducted by the first author, the interviews were recorded using a digital voice recorder and lasted 40 to 60 minutes depending on follow-up questions and probes. A total of 645 minutes was recorded, saved and transcribed verbatim. Semi-structured interviews required a questionnaire form to guide the flow of the conversation and remain on topic.

2.3. Data analysis

This study used a convergent mixed method with qualitative and quantitative data collection occurring concurrently and then integrated for analysis.

2.3.1. Grouping procedure

For quantitative analysis, the sample (N=47) was divided into high and low achieving groups to investigate the SRL skills of students with different achievement levels. The division into groups took place according to the students' average of the last two official studio grades, which were accepted as indicators of consistent achievement (see Boud & Falchikov, 2006; as cited in García-Pérez et al., 2020; Soderstrom & Bjork, 2015). Twenty-three students with grades above 77 (M=81.7, SD=4.06) were assigned to the high achieving group, and 24 students with

grades below 77 (M=65.8, SD= 8.51) were assigned to the low achieving group. Mann-Whitney U test showed the total scale scores for these two groups to be significantly different with mean rank for high achievers = 13.85, and mean rank for low achievers = 34.59 (U=32.5, z= -5.186, p < .001).

For qualitative analysis, 16 interview participants were again divided into two achievement groups. Six students with grades above 77 (M=83.6, SD=2.96) were assigned to the high achieving group, and 10 students with grades below 77 (M=66.6, SD=6.08) were assigned to the low achieving group. Mann-Whitney U test showed the total scale scores for these two groups to be significantly different again.

2.3.2. Quantitative analyses

In this study, Cronbach's alpha coefficient was calculated as 0.84 for the whole scale, 0.81 for Self-regulated Learning Skills and 0.67 for Motivation.

Descriptive statistics were used to describe the sample population. The normal distribution of the data was examined and confirmed: the Shapiro-Wilk test concluded that the significance value was higher than .05 in all sub-scales; Kurtosis and Skewness values were within the ±1 range for all variables, and the histogram chart showed the data had a normal distribution. However, as the sample size for each group was less than 30 participants, it was decided to use non-parametric tests. The Mann-Whitney U test was performed to determine which achievement level caused significant differences between scale mean scores.

2.3.3. Qualitative analyses

In this study, the first author, as a research assistant, had an active involvement in the design of the studio process from which the data were collected. Both the qualitative data collection and analysis process was based on constructivist grounded theory (CGT) because of the first author's active stance, relatively small sample and data construction with mutual interaction between the researcher and the research itself (see Arik & Arik, 2016; Charmaz, 2006; Strauss & Corbin, 1994, p. 273, 1990, p. 24)

The analysis of the interviews was conducted in two phases. In the first phase, we aimed to elucidate the elements of the studio processes and students' understanding by analyzing the data gathered from the interviews without theoretical assumptions. To follow up the procedure of CGT, data collection and analysis proceeded simultaneously and iteratively. The audio recordings were transcribed and transferred into the MAXQDA'18 Qualitative Data Analysis Program, which provided us with the tools to organize and analyze the data. As Charmaz (2021), the first step of coding, termed 'initial coding,' was carried out line-by-line using the interviewees' words (in vivo) whenever possible to preserve the sense of action. In vivo coding enabled us to see similar actions of the students with different statements and ask more focused follow-up questions during the interviews. The second step of coding proceeded with focused coding, which consisted of reviewing and synthesizing the initial codes and identifying relationships among them to create categories. In this phase, the transcriptions were grouped into the two achievement levels and the initial codes were reviewed within the groups to transform them into more abstract categories. Categories were reread and regrouped in relation to each other to develop patterns and create core categories.

In the second phase of the analysis, we aimed to identify the differences between high and low performers and the factors related to individual differences in SRL approach and motivation, with a more theory-driven approach. The descriptions in the categories were conceptualized and coded according to the SRL dimensions of Zimmerman's theory (2000; see Zimmerman & Moylan, 2009).

The first phase of the analysis was carried out by the first author, and the second phase was discussed in depth together with the second author.

2.3.4. Data integration

As this study followed a convergent mixed methods design, quantitative and qualitative findings were integrated under the guidance of the fifth research question. As suggested by Creswell and Plano Clark (2018) and O'Cathain (2010), a comparison matrix (Table 2)

was used to assess both data sets and determine the levels of agreement. There is agreement when the qualitative findings are explanatory, and 'dissonance' when findings are inconsistent. Such intra-method discrepancies can be harnessed to examine each data set more sufficiently (Moffatt et al., 2006). Thus, we used dissonances to identify potential explanations from theory (as cited in Fetters et al., 2013; Pluye et al., 2005). The coherence of the results is an important aspect of integration. Fetters (2013) identifies that the degree of integration, termed 'fit,' may either be confirmation, expansion or discordance. As the findings from the two sources diverge and expand the insights, the level of integration was considered as expansion in this study.

3. Results

The quantitative and qualitative analyses associated with each of the four research questions are presented in turn.

3.1. Results for quantitative analysis

The research question *Are there meaningful differences between the SRL skills and motivation of ID students with different academic achievement levels?* was studied using quantitative data. Descriptive statistics (Table 3) were used to describe the sample population. Means of SRL total and Motivation were calculated as 3.30±0.34, and 3.16±0.39, respectively. Within SRL factors, self-evaluation was the most frequently used, while seeking easily accessible information was the least used strategy. Within motivation factors, task value had the highest use whereas anxiety obtained the lowest scores.

Table 4 shows the differences between the SSRL mean scores of students, which were 235.3 (SS= 15.48) for high achievers and 205.1 (SS=16.41) for low achievers. To determine if differences are significant in scale scores between groups, the Mann-Whitney U test was run. Total scale scores were found to be significantly higher for high achievers (mean rank=13.85, U=32.5, z= -5.186, p< .001) than for low achievers (mean rank=34.59, U=32.5, z= -5.186, p< .001), as were the scores of subscales (i.e., SRL Total and Motivation).

Table 2. *Comparison of quantitative and qualitative findings.*

SRL strategies & Motivational factors	Quantitative	Qualitative	Agreement, partial agreement, dissonance, expansion, no match
Planning	++	+	Partial agreement
Environmental structuring	-		No match
Organizing and transforming	++	++	Agreement
Seeking appropriate information	-	+	Dissonance/Expansion
Seeking easily accessible information	-	+	Dissonance/Expansion
Rehearsing and memorizing	-		No match
Self-monitoring	-		No match
Seeking peer, teacher or adult assistance	-	+	Dissonance/Expansion
Self-evaluation	++	++	Agreement
Self-consequences after success	-		No match
Self-consequences after failure	++	++	Agreement
Self-efficacy	-	+	Dissonance/Expansion
Goal orientations	-	+	Dissonance/Expansion
Task value	++	+	Partial agreement
Attributions for failure	++	++	Agreement
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

Table 3. *Descriptive statistics of scale results of students.*

SRL Skills	N	Number of items	Mean	Std. Deviation	Minimum	Maximum
Arrangement of study time	47	4	2,98	0,59	1,75	4,00
Planning	47	5	3,09	0,58	1,80	4,40
Environmental structuring	47	4	3,78	0,87	1,00	5,00
Organizing and transforming	47	5	3,50	0,76	2,20	5,00
Seeking appropriate information	47	3	3,12	0,74	2,00	4,67
Seeking easily accessible information	47	2	2,30	0,95	1,00	4,50
Rehearsing and memorizing	47	4	3,15	0,58	2,00	4,50
Self-monitoring	47	2	3,55	0,96	1,00	5,00
Seeking peer, teacher or adult assistance	47	3	3,60	0,79	1,67	5,00
Self-evaluation	47	6	3,84	0,73	1,83	5,00
Self-consequences after success	47	4	2,94	1,20	1,00	5,00
Self-consequences after failure	47	3	3,45	1,00	1,00	5,00
SRL Total	**47**	**45**	**3,30**	**0,34**	**2,33**	**3,92**
Self-efficacy	47	5	3,63	0,65	2,00	4,60
Goal orientations	47	3	3,18	0,93	1,33	5,00
Task value	47	5	4,03	0,87	1,00	5,00
Attributions for failure	47	4	2,56	0,81	1,00	4,50
Anxiety	47	5	2,42	0,73	1,00	4,00
Motivation	**47**	**22**	**3,16**	**0,39**	**2,41**	**4,04**
SSRL TOTAL	**47**	**67**	**3,24**	**0,31**	**2,44**	**3,90**

Table 4. *Group statistics and Mann-Whitney U test results of scale and subscale scores of students with different achievement levels.*

Dimensions	Achievement Level	N	Mean	Std. Deviation	Std. Error Mean	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
SSRL TOTAL	High achieving	23	235,3	15,48	3,23	32,500	332,500	-5,186	**0,000***
	Low achieving	24	205,3	16,41	3,35				
SRL Total	High achieving	23	159,87	11,226	2,341	62,500	362,500	-4,548	**0,000***
	Low achieving	24	139,67	14,699	3,000				
Motivation	High achieving	23	75,43	6,953	1,450	91,000	391,000	-3,944	**0,000***
	Low achieving	24	65,63	7,534	1,538				
Arrangement of study time	High achieving	23	12,26	2,508	0,523	225,500	525,500	-1,084	0,278
	Low achieving	24	11,58	2,244	0,458				
Planning	High achieving	23	16,48	2,937	0,612	159,000	459,000	-2,507	**0,012***
	Low achieving	24	14,42	2,483	0,507				
Environmental structuring	High achieving	23	15,87	2,719	0,567	219,000	519,000	-1,220	0,222
	Low achieving	24	14,38	3,998	0,816				
Organizing and transforming	High achieving	23	19,65	2,587	0,539	92,500	392,500	-3,938	**0,000***
	Low achieving	24	15,38	3,609	0,737				
Seeking appropriate information	High achieving	23	9,826	2,3091	0,4815	209,500	509,500	-1,432	0,152
	Low achieving	24	8,917	2,0834	0,4253				
Seeking easily accessible information	High achieving	23	4,74	1,912	0,399	247,500	547,500	-0,616	0,538
	Low achieving	24	4,46	1,911	0,390				
Rehearsing and memorizing	High achieving	23	12,91	1,952	0,407	214,500	514,500	-1,329	0,184
	Low achieving	24	12,25	2,609	0,532				
Self-monitoring	High achieving	23	7,65	1,968	0,410	202,000	502,000	-1,597	0,110
	Low achieving	24	6,71	1,805	0,369				
Seeking peer, teacher or adult assistance	High achieving	23	11,22	1,704	0,355	230,000	530,000	-0,987	0,323
	Low achieving	24	10,46	2,734	0,558				
Self-evaluation	High achieving	23	25,00	3,162	0,659	122,000	422,000	-3,289	**0,001***
	Low achieving	24	21,00	4,709	0,961				
Self-consequences after success	High achieving	23	12,83	3,881	0,809	215,500	515,500	-1,291	0,197
	Low achieving	24	10,88	5,245	1,071				
Self-consequences after failure	High achieving	23	11,43	2,826	0,589	151,500	451,500	-2,665	**0,008***
	Low achieving	24	9,25	2,848	0,581				
Self-efficacy	High achieving	23	19,09	2,875	0,599	204,500	504,500	-1,530	0,126
	Low achieving	24	17,42	3,348	0,683				
Goal orientations	High achieving	23	9,91	2,811	0,586	257,500	557,500	-0,397	0,692
	Low achieving	24	9,42	2,873	0,586				
Task value	High achieving	23	21,65	3,393	0,707	175,500	475,500	-2,151	**0,031***
	Low achieving	24	18,79	4,690	0,957				
Attributions for failure	High achieving	23	11,57	3,160	0,659	146,000	446,000	-2,785	**0,005***
	Low achieving	24	8,92	2,858	0,583				
Anxiety	High achieving	23	13,22	3,343	0,697	196,000	496,000	-1,708	0,088
	Low achieving	24	11,08	3,670	0,749				

Table 5. *The emerging main themes and their sub-categories of the qualitative analysis.*

1.0 Student theme: feelings and thoughts of industrial design students

- 1.1 Comments on their strength and weakness
- 1.2 Interpretation of success in the studio

2.0 Project theme: expressions of industrial design students

- 2.1 Strategies they applied
- 2.2 Interpretations in the process
- 2.3 Comments on the outcome

3.0 Studio theme: external factors industrial design students are exposed t

- 3.1 Peer interaction
- 3.2 Feedbacks
- 3.3 Managing information

Table 6. *Representative quotations in student theme: feelings and thoughts of industrial design students.*

Subthemes:	Representative quotations of low achiever design students	Representative quotations of high achiever design students
Comments on their strengths and weaknesses	*"I'm very bad at making models. I wish there were not any obligatory models for projects." (L.5)* *"I definitely cannot think in an abstract way. I wish [this skill] was taught to me in my first year." (L.12)*	*"I thought that presentation was my strong skill, but when I see the other works, I realized that it was not as good as I believed. So, this term, I mostly focused on developing my presentation skills as well." (H.11)*
Interpretations of success in the studio	*"I thought my project subject was not different enough. That is why I got a lower grade than others. For example, someone seemed successful because she chose a very different subject and drew the attention of the instructor." (L.5)* *"I tried to find an uncommon thing that would interest instructors more." (L.3)*	*"To be successful in the studio means keeping the project subject in your mind every time and everywhere and embracing the subject when you did not like it. Pushing yourself to like it. Not giving up." (H.14)* *"Success in studio depends on the first impression of the instructors. Sincere interaction is important." (H.16)*

To answer the second research question *What are the SRL skills frequently used by ID students with different academic achievement levels?* the students' overall average score, together with subscales for each SRL skill and motivational factors, were compared. According to Mann-Whitney U test results (Table 4), student achievement levels differed significantly when comparing scores for planning, organizing and transforming, self-evaluation and self-consequences after failure. High achievers were better at planning their studies, rearranging their instructional materials, evaluating their work and consequences after failure. High achievers had significantly higher scores for task value and attribution for failure, which means they appreciated what they learned more than low achievers, and they attributed their failure to controllable factors such as their lack of effort.

3.2. Results for qualitative analysis

Descriptive statistics were used to describe interviews with 16 students, consisting of 6 high achievers (5 females, 1 male) and 10 low achievers (5 females, 5 males). The means of total SSRL scores were 241.3 (SS=14.61) for high achievers and 198.6 (SS=22.67) for low achievers. Another Mann-Whitney U test was run and total SSRL scores were found to be significantly higher for high achiever interviewees (mean rank = 13.50) than for low-achiever interviewees (mean rank=5.50) (U=0, z=-3.259, p< .001). The groups of low and high achievers were the determinants in the interview data analysis enabling to build the descriptive statistics.

To answer the third research question, *How do high and low achieving ID students perceive their own studio course experiences?*, interview data were analyzed using the CGT approach. The emerging main themes and their sub-categories are presented in Table 5. This section includes key findings on student studio experiences with representative quotations in Table 6,7 and 8; and discusses them through SRL strategies.

3.2.1. Analysis of themes

In the qualitative analysis, the data obtained from the interviews were classified under three main themes: student, project and studio. Representative quotations from the students are shown in Tables 6, 7 and 8.

3.2.1.1. Student theme: Feelings and thoughts of industrial design students

This student theme contained students' feelings and thoughts about themselves and their project experience. Through scrutinizing their feelings and definitions, we aimed to understand the differences in awareness due to achievement level in the studio course. Under this theme, we examined (a) comments on their strengths and weaknesses, and (b) interpretations of success in the studio. Table 6 provides representative quotations for this theme.

Students in both achievement groups were aware of their strengths and weakness, showing evidence of good metacognitive skills. However, high achieving students embraced their weaknesses and explained what they had done to strengthen them. In contrast, low achieving students expected to be taught to address their weaknesses. These attitudes indicate that low achievers need more metacognitive regulation, especially in self-evaluation and self-consequences.

Low achievers believed that finding a different project topic and developing it based on instructors' predispositions was sufficient for studio success. In contrast, high achievers had a sense of ownership in the process through participating and being able to interact with the instructor. Low achievers considered tasks as the opportunity to gain positive comments from instructors, while high achievers mentioned learning-oriented goals such as benefits for their improvement. The difference in goal orientation and task value indicated problems in low achievers' motivational regulation.

3.2.1.2. Project theme: Expressions of industrial design students

This project theme included students' expressions of their behaviors and discourses (e.g., homework, presentation, process experience and learning experience). We focused on analyzing students' descriptions of what they did during their project. In this theme, (a) strategies, (b) interpretations and (c) comments on the outcome were examined. Table 7 provides representative quotations.

The students' descriptions indicated that they found it hard to decide between realistic or conceptual projects, stated as developing either a functional product or a meaningful one. Low achieving students complained about their difficulties with a meaning-focused approach and even attributed their low grades to this. This indicates evidence of deficiency for developing appropriate strategy. By contrast, high achievers approached their designs in a more integrated way. The challenge in deciding on specific task strategies indicates problems related to understanding the project holistically and using self-instruction.

The students demonstrated effective self-evaluation skills when they described their studies in the studio. They criticized their own behavior and work. They were highly aware of what they had been doing. However, when describing specifically their study for tasks, it was clear that high achievers developed their projects by interpreting the tasks, feedback, and experiences from other courses. This is evidence of high achievers' integrative approach. In contrast, low achieving students submitted the tasks with minimal effort without interpretation, were highly influenced by examples and likes, fixated on given ideas and lost their motivation in the face of harsh criticism. The low interpretation attitude revealed problems with cognitive and metacognitive regulation.

Table 7. *Representative quotations in project theme: expressions of industrial design students.*

Subthemes:	Representative quotations of low achiever design students	Representative quotations of high achiever design students
Strategies they applied	*"I could not understand which part I should focus on product or meaning. Finally, I could not find any meaning for my product, and failed." (L.5)*	*"I thought about approaching my project in a functional way (product-oriented) or meaningful way. Then I found a way to synthesize the story (meaning) and the product (function)." (H.11)*
Interpretations in the process	*"In my critic session, the idea of an island bathroom came up – indeed, it was not my idea. After that, I lost control and got off the subject. I could not explain what I am doing and why I am doing this. Later on, I saw others' projects they were working on, such as flowers, pots, etc. I started to ask myself: Could I have these kinds of extreme (crazy) ideas, too? I wanted to design a product, but on the other hand, everyone was flying (a common saying for having extreme or crazy ideas), and I wanted to fly too, which I could not." (L.5)*	*"I think I'm good at the studio. I study, I make a great effort. I believed that I analyze the feedback very well, so I know my mistakes. I write down almost everything. That's the point that makes me strong. When an instructor says something to me which I do not agree with, I fix it (interpret it) in my own way. I always compare my work by watching the others' work, and so I can understand whether I'm successful or not." (H.16)*
Comments on the outcome	*"I liked my first idea, but not the process. I felt like I got stuck and could not find anything... I wish I did something different than that (the project). I think I started in the wrong way... I mean, if I did my research better, I could do a better project. Hopefully, I can learn how to do that maybe in my first job." (L.20)*	*"I cannot say it is over. Projects need to get a final presentation once the term finishes, but I think they never end. I liked working on it, after all. There are still things to develop, and I'm planning to develop my project to put in my portfolio." (H.10)*

The students also commented on the outcomes differently. High achievers wanted to improve the whole process by deducing from their experiences and believed that a project never ends. They had short-term action plans with long-term goals. Low achievers were oriented further in the future. They did not enjoy the process, wanted to change it entirely and believed that they would learn eventually in their professional lives. Self-commenting on outcome defensively or offensively affected motivation and goals directly.

3.2.1.3. Studio theme: External factors to which industrial design students are exposed

The third category was about the external factors to which students are exposed (e.g., studio subject and description (project brief), studio space, instructors and peers). Students were encouraged to talk about external factors to the studio such as the brief, studio environment, instructors, peers and other factors affecting their project process. Under this theme, (a) peer interaction, (b) feedback and (c)

Table 8. *Representative quotations in studio theme: external factors to which industrial design students are exposed.*

Subthemes:	Representative quotations of low achiever design students	Representative quotations of high achiever design students
Peer interaction	*"It is very hard for me to adapt here (in the studio). I prefer to study at home, alone. The studio is more like meeting friends, chatting, eating. When I try to study in the studio, I need to get up every 15 minutes, walk around, and I see others' works so I cannot focus on my ideas." (L.17)* *"When I saw someone's project presentation in the midterm jury, I felt discouraged. The subject she was working on was not so fancy, but the process she performed was highly developed. After that, I decided not to look at her work at all… before submitting my work, I checked the other work submitted in the folder (online submission platform). If they are as bad as mine, I feel comfortable." (L.5)*	*"I like to study in the studio. I do not feel sleepy since everyone works, and it makes me feel more motivated." (H.11)* *"We (peers) always talk about our projects, even during our breaks in the studio. When I see or think something about my friends' projects, I tell them and we discuss it together, for example, while drinking our coffee in the break." (H.14)*
Feedback	*"In the critic sessions or juries, I feel demoralized because of the way we are criticized. I know that I should not get offended personally, but I did. I feel degraded. I don't even care about the grade at that moment. The critiques should have been given more gently and kindly." (L.3)* *"Since my project went badly, even when I came eye to eye with the instructor in the studio, I felt stressed. While having my critique, my hand was shaking. Sometimes I got the impression from the teachers that they wanted to get out of my session. I thought they did not want to listen to me at all." (L.17)*	*"In a critic session, my idea was criticized heavily. That session was my turning point. I started to think more seriously." (H.1)* *"Soft critics make me happy, but I cannot keep it in my mind. But heavy criticism stays in the mind for weeks, affecting me so much more positively." (H.14)* *"Sometimes I ask other instructors in the department since they can offer more realistic critique as an outsider." (H.10)*
Managing information	*"First, I searched on the internet for designs of this kind of object. I saw some rope and shelters. I like these kinds of materials, so I thought there could be small modules like this… after a while, I saw that the thing in my mind was already designed, and I was very sorry. I searched the designer's work deeply, and I changed my project according to myself." (L.7)* *"I searched on the internet about the keywords in the brief, but it was not helpful for me. I wanted to see what kind of concepts I'm interested in… finally, I decided on something when I saw some projects on sports areas I'm familiar with." (L. 20)*	*"Mostly I search on the internet for my presentations. I think it is also important. I want to trust my visual presentation to talk about my ideas confidently." (H.11)* *"I did my research to understand the problems in public toilets. I mostly read forums or some documents about it." (H.10)*

managing information were examined. Representative quotations are presented in Table 8.

The students' descriptions suggest that high and low performers interact with their peers differently. High achievers enjoyed studying together and commenting on other projects motivated them. They liked spending time in the studio. Low achievers preferred to study individually – mostly at home. They expressed feeling psychological pressure when studying in the studio and having low productivity due to other students' presence. They were adversely affected by others' achievements and relieved by the failures of peers. Avoiding interaction with peers indicates problems with the regulation of behaviors such as seeking help.

The descriptions about the feedback (critiques) indicated variety in the students' self-efficacy beliefs. High achievers mentioned that they stayed motivated after harsh criticism, which was more effective and helpful than being praised or gently critiqued. They learned the most from strong criticism. Students emphasized the value of asking for extra comments from the other instructors. Conversely, low achievers mentioned that they were hesitant and avoided meeting the instructors. They became demoralized after harsh criticism and lost their confidence. High achieving students seemed to have greater self-efficacy beliefs than underperformers.

In their third year, the design studio provides students with more opportunities for self-process time,

which means students need to develop their projects by doing desktop or field research by themselves in addition to homework and feedback from the instructors. When describing their self-process time, differences in the purpose of research became clear. High achievers researched on the Internet after they had decided on their subject. In contrast, low achievers went online to decide their subject. The difference in the purpose of research indicates problems in seeking appropriate information – a sub-dimension of behavioral regulation.

3.3. Integrating the quantitative and qualitative results

To respond to the fifth research question To what extent do qualitative and quantitative results converge?, we merged the quantitative and qualitative databases using a weaving approach that makes intragroup comparisons of the results into a type of narrative integration (see Fetters et al., 2013). We considered the quantitative and qualitative data analysis together on a theme-by-theme basis and determined that the qualitative data expanded the findings of the quantitative component. This allowed us to exemplify the statistical differences in the context of studio education and illustrate these differences with essential aspects of Zimmerman's SRL model (see Zimmerman & Moylan, 2009). Some strategies high and low achievers used during their projects were prominent in both data sets (see Table 2). Organizing and transforming, self-evaluation and self-consequences after failure were significantly different for the two student groups. Specific information from interview descriptions related to these aspects. Additionally, planning, task value and attribution for failure were statistically different with supporting descriptions from qualitative data. There were also some inconsistencies in the findings. Despite no statistical differences, our qualitative results revealed differences in seeking assistance, self-efficacy and goal orientation. We discuss these aspects further in the discussion.

4. Discussion

4.1. Main findings

The study aimed to explore differences in SRL strategies and motivational factors between high and low achieving ID students in a studio course. We used a convergent mixed methods design to gain a comprehensive understanding of the students' strategy use. The integrated analysis demonstrated that there were differences between high and low achieving students' SRL skills concerning the use of metacognitive, motivational and behavioral strategies.

Comparing the quantitative and qualitative results illustrated that the metacognitive strategies of organizing and transforming, planning, self-evaluation and self-consequences after failure were different for the two groups in both data sets. High achieving students interpreted project brief, tasks, feedback, experiences drawing or writing, and changed strategy according to their understanding. These findings align with research pointing out the adaptive inferences and SRL patterns of high achieving students (e.g., DiFrancesca et al., 2016; Nandagopal & Ericsson, 2012; Pintrich & de Groot, 1990; Powers, 2006; Zimmerman, 2008). The lack of interpretation deters low achievers from developing their autonomy which is a crucial feature for the creative endeavor in design education (Tudor, 2008). This may explain the dependency of low achievers on external factors such as being easily influenced by examples or praise from others, especially instructors. Design students are expected to be independent, self-analytical and critical thinkers (Tovey, 2015) and the form of studio education generally produces this kind of learners. However, our results demonstrated that students could have very different experiences in the same studio and some struggle to find their way (Shreeve, 2015). These findings may caution studio educators to accept individual differences, engage metacognitive strategies and encourage students to understand their learning journeys.

Within metacognitive strategies, the differences in self-evaluation of the student groups were at a differ-

ent level. Despite the significant difference in the quantitative analysis, students' descriptions revealed that they were all aware of their strengths and weaknesses. This qualitative result is consistent with Zimmerman and Pons' (1986) self-evaluation finding – the only strategy nonrelated to academic achievement. However, deeper conversations and observations during interviews supported the quantitative results that low achievers were evaluating themselves while answering our question. This confirms the notion that multidimensional assessment approaches have more potential to understand human regulation (see Cleary et al., 2012; Tas & Sungur, 2012) and capture these nuances. Low achieving students complained about the problems they encountered, attributed their weaknesses to the education system, and expected the instructors to teach them how to make self-adjustments and overcome difficulties. In their SRL model, Zimmerman and Moylan (2009) place self-evaluation and casual attribution together due to their interdependence, and our results fit well with that. Attribution to external and uncontrollable factors discourages efforts to develop, undermines self-motivation (Schunk, 2007; Weiner, 1992; as cited in Zimmerman & Moylan, 2009) and reduces ownership which is a motivational necessity for students (Powers, 2006). Self-critique reduces dependence on others and helps develop self-regulatory learning skills (Crolla et al., 2019; Greene, 2018). Our findings indicate that underachieving design students need to be encouraged in self-judgment during the studio process through focusing on controllable causes rather than defensive decisions.

Quantitative analysis revealed motivational factors (task value, attribution for failure and the overall scores) as notable predictors of academic performance. Student interviews enabled us to further discover the differences in goal orientation and self-efficacy factors. Low achievers defined studio success as having positive critique from instructors, which demonstrated their performance-oriented goal. Their frailty in the face of harsh criticism also indicated low self-efficacy. Our integrated findings support and expand on previous studies mentioning the relationship between motivation, SRL and academic achievement (e.g., Araz & Sungur, 2007; Eckerlein et al., 2019; Erdogan & Senemoglu, 2016; Kryshko et al., 2020; Meece, 1994; Pintrich & Schunk, 2002; Zimmerman, 2000; Zimmerman & Moylan, 2009). Students need to be motivated to navigate the complexity of design education by accepting mistakes, obstacles and risks, and developing methods for handling tasks and self-evaluating learning performances (Fadlelmula et al., 2015; Garner & Evans, 2015; Powers, 2016)

In contrast to quantitative results, qualitative data exemplified differences in behavioral strategies between the high and low achieving groups. High achievers were more open to peer and teacher interaction. They preferred to seek the help of others, study together and believed in learning better in this way. Low achievers were reluctant to have comments from peers or instructors to avoid demoralization. These findings are in line with studies considering these resource management strategies as self-regulatory processes and predictors of academic achievement (e.g., Englert & Mariage, 2003; Greene et al., 2015; Karabenick & Gonida, 2018; Newman, 2008; Zimmerman & Cleary, 2009; Zimmerman & Martinez-Pons, 1990). Reluctance to seek help mostly relates to a lack of awareness of the need for help (Greene & Azevedo, 2009), lack of social competencies or, as stated in interviews, fearing criticism (Karabenick & Knapp, 1988). From this standpoint, problematic communication between underachieving students and instructors should be considered. Critique sessions are the fundamental tool of reflective conversations in studio education. They also improve the metacognitive skills of design students (Greene, 2018). Yet, if the critiques mostly point out weaknesses or mistakes, students may avoid attending the sessions or misinterpret the comments (Goldschmidt et al., 2010). Inaccessibility of the instructors – described as

'mystery-mastery' syndrome by Schön (1987) may prevent underachieving students from asking for help and decrease their self-confidence. Criticism should be given in a scaffolded manner that supports underachieving students to use external resources appropriately.

The most remarkable result emerging from the qualitative data was the dilemma faced by students. Both high and low achievers reported difficulty in deciding on a strategy for developing their projects, which they described as the dilemma of product vs. meaning. High achievers managed to integrate their ideas – exemplifying a cognitive strategy for critical thinking (Paul, 1989) – but the perception of contradiction caused underachievers to choose what seems easy. These findings broadly follow research showing the correlation between SRL, critical thinking and academic achievement (e.g., Gaythwaite, 2006; Oz, 2019; Paul & Elder, 2005; Phan, 2010; Seferoglu & Akbiyik, 2006). The cognitive strategies such as moving from abstract to concrete, analysis to synthesis or information to interpretation are seen as a skill of critical thinking (Paul & Elder, 2005), a process of innovation (Beckman & Barry, 2007), a creative production (Orlandi, 2010), a representational transformation (Casakin & Goldschmidt, 1999; Oxman, 1999) and a designer's skill (Powers, 2016; Tobón et al., 2021; Voûte et al., 2020). The ability to synthesize and interpret provides students with cognitive strength to deal with the complexity and ambiguity of design projects (Austerlitz et al., 2008; Shreeve, 2011). Fostering SRL strategies in the design studio may help underachieving design students to develop the higher order thinking skills needed to cope with ill-defined problems.

4.2. Limitations and further studies

Our integrative analysis revealed the difficulty in recognizing the SRL skills of students via one kind of data source. On its own, our quantitative data indicated statistical differences in strategy use between the two achievement groups. However, it provided little insight into how and why this occurs. We did not ask about or mention any SRL strategies during interviews, and this enabled us to obtain non-biased descriptions by which we could go beyond statistics and realize other internal and external components that might affect design students' SRL process. The integrated approach led to a reconsideration of the complex and ambiguous design learning process. The inconsistent findings between the data sets (mostly in behavioral and motivational factors) also highlighted an important limitation about self-report for further studies. Some studies have questioned the effectiveness of self-report for capturing factual information (e.g., Winne & Jamieson-Noel, 2002) and dependency on the context of use (e.g., Alexander et al., 2011; DiFrancesca et al., 2016). Even though the questionnaire used in our study was designed as context-free and suitable for [anonymized] undergraduates (Erdogan & Senemoglu, 2016), we had to optimize the terms according to studio expressions. Therefore, it may not completely capture accurate information in a design education context. Future research might therefore benefit from a self-report study with a design-education-oriented approach or using additional SRL measurements that monitor and track learners' ongoing development.

The sample size was constrained to 47 participants completing the questionnaire and 16 participants being interviewed. Our results are promising and should be validated by a larger sample size. Further, our study focused on a small group of junior undergraduates majoring in ID in a [anonymized] university. For this reason, caution is recommended concerning the findings' generalizability and external validity. Future research would benefit from multiple content areas, different design disciplines and students at various levels of study. Aside from a small number of studies, the design domain in SRL studies is under-researched and had not yet been studied in [anonymized]. We believe that our research will serve as a base for future studies on this topic.

4.3. Conclusion

Using a convergent mixed-methods approach, this study has taken steps toward describing differences in the self-regulation skills of high and low achieving ID students in a design studio

course. The interview findings expanded the self-report questionnaire results, presented new insights, and provided a detailed understanding of the statistical results. By this study, we anticipate our contribution in two levels. First, it provides insights for education literature from design studio education which is a creativity focused learning environment with natural learning condition and simulation of real-life. Second, regarding the ongoing deep changes in both educational, theoretical and practical sides of design -which is signifying a new order of design and a new generation of designers who tend to become decisionmakers- 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, strategy preferences and purpose of learning in studio education. Thus, we aimed to better understand design learning and provide further insights for redesigning the studio learning experience. To further our research, we intend to conduct an intervention in a design studio course, where the specific SRL strategies and phases will be integrated into the studio process targeting underachieving students' needs. 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 implication of SRL strategies regarding individual differences in design learning environments can help to improve the design performance of less accomplished students.

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