Iranian Educational Psychology Association

Iranian Journal of Learning and Memory

Print ISSN: 2645 - 5455
Online ISSN: 2645 - 5457

Homepage: https://journal.iepa.ir

The Relationship between Self-directed Learning and Problem-Solving: The Mediating Role of Self-Regulated Learning and the Moderating Role of Gender among University Students

Ansaf Jasim Imran[1], Ilnaz Sajjadian[2]✉, Ali Hussein Mazloum Al-Mamouri[3], and Mohammad Ali Nadi[4]

1. Department of Psychology, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran. E-mail: stuid40017520735423@khuisf.ac.ir
2. *Corresponding author*, Department of Clinical Psychology, Community Health Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran. E-mail: i.sajjadian@khuisf.ac.ir
3. Department of Educational Psychology, Faculty of Psychology, University of Babylon, Iraq. E-mail: Hum.ali.hussain@uobabylon.edu.iq
4. Department of Educational Psychology, Community Health Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran. E-mail: mnadi@khuisf.ac.ir

Article Info

Article type:
Research Article

Article history:
Received July 28, 2024
Received in revised form September 13, 2024
Accepted September 22, 2024
Published online September 25, 2024

Keywords:
self-directed learning, problem-solving, self-regulated learning, students

ABSTRACT

Objective: This study aimed to investigate the relationship between self-directed learning (SDL) and problem solving, with a focus on the mediating role of self-regulated learning (SRL) and the moderating role of gender among Iraqi university students.

Method: A correlational research design was employed. The statistical population included all the students of Qadisiyah University in Iraq in the academic year 2023-2024. A sample of 300 students was selected using a convenience sampling method. Data were collected using the Problem-Solving Inventory (Cassidy & Long, 1996), the Self-Directed Learning Readiness Scale (Cheng et al., 2010), and the Motivated Strategies for Learning Questionnaire (Pintrich & De Groot, 1990). Data were analyzed using Pearson correlation coefficient and Structural Equation Modeling (SEM) using SPSS and AMOS software.

Results: The results indicated a good model fit. SDL had a direct impact on problem solving. Additionally, SRL partially mediated the relationship between SDL and problem solving. However, gender did not significantly moderate the relationship between SRL and problem solving.

Conclusions: The findings suggest that increasing SDL and SRL among students can enhance their problem-solving skills.

Cite this article: Jasim Imran, A., Sajjadian, I., Al-Mamouri, A. H. M., & Nadi, M. A. (2024). The Relationship between Self-directed Learning and Problem-Solving: The Mediating Role of Self-Regulated Learning and the Moderating Role of Gender among University Students. *Iranian Journal of Learning and Memory*, *7* (27), 5-21. DOI: https://doi.org/10.22034/iepa.2025.493481.1510

© The Author(s).
Publisher: Iranian Educational Research Association.
DOI: https://doi.org/10.22034/iepa.2025.493481.1510

Introduction

Among the 21st-century skills students need to master are metacognitive skills and problem-solving abilities (Muhali, 2019; Trilling & Fadel, 2009). In higher education, students need these abilities as a learning outcome in the classroom, as these skills prepare graduates to engage with the challenges of the modern world (Arsanti et al., 2021). Problem-solving skills contribute to academic achievement and improve class averages. These skills also help students in academic careers and in facing life's challenges (Almull & Al-Rahmi, 2023). Problem-solving refers to working on issues for which the solver does not have a previously learned plan or algorithm. This process involves two types of structure: the internal structure (metacognitive processes such as exploration and evaluation) and the external structure (observable actions such as "understanding the problem" and "devising a plan") (Philip, 2013; Schönfeld, 1985; as cited in Rott et al., 2021). Heppner (1988) introduced three structures in the problem-solving process: a sense of adequacy in solving problems, personal control over emotions and behaviors, and avoidance-oriented coping styles. Research evidence suggests that metacognitive variables, particularly self-assessment, play a crucial role in problem-solving. Furthermore, researchers have found that learning preferences impact problem-solving skills (Almull & Al-Rahmi, 2023). In other words, problem-solving is a form of advanced learning in which individuals combine simpler issues to find more complex solutions, ultimately acquiring new knowledge and skills (Saif, 2009). It is stated that components of creativity, learning styles, learning objectives, and learning domains must be taken into account for improving the problem-solving ability (Ebrahimi Zarandi et al., 2020).

Self-directed learning (SDL) can be associated with problem-solving skills because, in the process of solving a problem, which is a reflective judgment process, individuals monitor their actions and outcomes, adjusting strategies when necessary. This clinical judgment requires self-regulation (Almull & Al-Rahmi, 2023; Canniford & Fox-Young, 2015; Kim et al., 2020; Kim & Seo, 2021). On the other hand, as mentioned earlier, one of the structures of problem-solving is metacognitive, and learning strategies also include methods ranging from memory-enhancing techniques to testing and studying. Flavell divided these strategies into two categories: cognitive strategies for facilitating learning and completing tasks, and metacognitive strategies for reviewing progress (cited in Zarei & Marandi, 2011). Long (2000) also considered three dimensions—motivation, metacognition, and self-regulation—as critical for SDL (as cited in Yousefy & Gordanshekan, 2010), which enable an individual to independently and efficiently manage their learning process (Brockett & Hiemstra, 2018). SDL is a key competency for adults in the modern world, providing them with the ability to adapt to changing social conditions and is essential for success in life and work (Morris, 2019). Research by Tafaroji Gilanvandani et al. (2021) found that self-regulated learning strategies influence the problem-solving methods of high school students.

Similarly, studies by Hwang and Oh (2021) and Leary et al. (2019) showed a connection between SDL and problem-solving skills.

Self-regulated learning (SRL) is also linked with both SDR and problem-solving (Baars et al., 2017; Faridian et al., 2021; Qasemi et al., 2021; Van Gog et al., 2020), and to some extent mediates the impact of learning interventions on higher education progress (Jansen et al., 2019). Despite the close relationship between self-directed learning and self-regulation in some areas, these concepts are not identical. SRL primarily refers to internal effects while SDL refers to both internal and external influences (Olivier & Wentworth, 2021). One goal of education is to help individuals set and achieve their goals. To do this, individuals need to adapt when goal pursuit is not progressing well. Moreover, self-regulation involves efforts to initiate, guide, and strategically manage goal pursuit through metacognitive planning, monitoring, evaluating, and adjusting cognitive, behavioral, motivational, and emotional factors (Greene et al., 2024). SRL is a goal-oriented and self-control behavior that includes motivational and cognitive aspects. High-performing students use appropriate self-regulated learning strategies while low-performing students tend to put in less effort. Zimmerman (1986) defined SRL as the active participation of the learner in the learning process to optimize outcomes. Self-regulation includes the optimal use of resources, applying motivational and cognitive strategies, and metacognitive management, which plays a critical role in academic success and health promotion (Broadbent, 2017). In other words, metacognition directs individuals' thought processes in learning situations as such it leads to the better formation of self-regulated learning (Aghdar et al., 2020). The ability to self-regulate allows individuals to control and monitor their behavior, evaluate it against their own standards, and act on personal growth and others' actions (Cadorin et al., 2017). Research by Hwang and Oh (2021) found that the relationship between SDL and problem-solving ability is partly mediated by SRL, and studies by Tafaroji, Gilanvandani et al. (2021) and Van Gog et al. (2020) showed that SRL impacts problem-solving. Furthermore, research by Ebadi and Muaqar (2021) highlighted the impact of self-directed learning on SRL.

Gender is one of the factors influencing academic performance. Previous research has shown that female students tend to perform better than males, particularly in reading and writing. Some studies have suggested a significant relationship between SDL and gender, although the findings were mixed (Grover & Miller, 2014; Hayes & Flannery, 2000; Osman, 2015; as cited in Nordin et al., 2016; Tekkol & Demirel, 2018). For example, research by Alersan (2017) indicated no statistically significant gender differences in problem-solving skills while other studies suggest a moderating role of gender in SRL (Alghamdi, et al., 2021; Samadi, 2004). Considering the findings of previous research on the relationships between the variables of this study and the significant impact these variables have on academic performance, student's progress, and success in later life,

and noting that no similar study has been conducted in Iraq, this research sought to answer the following question:

- How does SDL impact problem-solving, and what is the mediating role of SRL and the moderating role of gender?

The conceptual model of the study is illustrated in Figure 1.

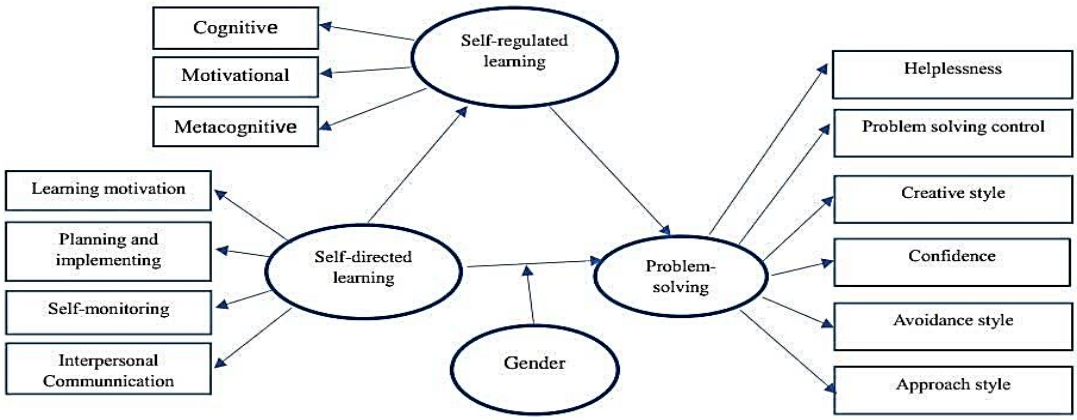

Figure 1. Conceptual Model of the Study

Materials and Methods

Design of the Study

The research method was correlational, falling under the category of descriptive designs, and it was conducted using Structural Equation Modeling. In this study, the relationship between one predictor variable and one criterion variable was examined, with the mediation of one variable and moderation of another variable.

Participants

The study population included all students from Al-Qadisiyyah University in Iraq during the 2023-2024 academic year. According to Fritz and MacKinnon (2007, p. 14), 200 participants are the minimum sample size for conducting mediational and moderational research with .80 statistical power and medium (0.30) effect size. In this study, a sample of 300 students was used, meeting and exceeding the minimum sample size whom responded to the questionnaires. The inclusion criteria included: 1) voluntary and informed consent to participate, 2) enrollment in a university program at Al-Qadisiyyah University. The exclusion criteria was incomplete questionnaire responses. The data were analyzed using Pearson correlation coefficients, Structural Equation Modeling, through SPSS 26 and PLS 3.2.8 software.

Instruments

Problem-Solving Styles Questionnaire (PSSQ): The Problem-Solving Styles Questionnaire, developed by Cassidy and Long (1996), consists of 24 items and 6 subscales (Helplessness, Self-Control, Creativity, Confidence, Approach, and Avoidance) on a three-point Likert scale (Yes, I Don't Know, No) for scoring. Scoring is done as 0 for "No," 1 for "Yes," and 0.5 for "I Don't Know." The maximum score for each factor is 4, and the minimum is 0. A higher score in any subscale indicates that the participant tends to use that strategy more frequently when solving problems. The maximum possible total problem-solving score is 24, and the minimum is 0. In their study, the developers reported Cronbach's alpha coefficients of .66 for helplessness, .66 for self-control, .57 for creativity, .71 for confidence, .52 for avoidance, and .65 for approach. In another study, the Cronbach's alpha coefficients for these subscales were reported as .86, .60, .66, .66, .51, and .53, respectively. The Internal Consistency of the subscales was reported as follows: helplessness (.86), self-control (.66), avoidance (.71), confidence (.52), approach (.65), and creativity (.66) (Cassidy & Burnside, 1996). In the study by Bapapour Kheirodin et al. (2003), Cronbach's alpha was reported as .77, and the Validity Coefficient was .87. In this research, the Cronbach's alpha for this questionnaire was .791.

Self-Directed Learning Inventory (SDLI): The Self-Directed Learning Inventory (SDLI) was designed by Cheng et al. (2010) to assess self-directed learning in university students. This questionnaire contains 20 items, with responses on a 5-point Likert scale ranging from "Strongly Agree" (5) to "Strongly Disagree" (1). It measures four dimensions: learning motivation, planning and execution, self-monitoring, and interpersonal relations. The minimum score on this questionnaire is 20, and the maximum is 100. Due to differences in the number of items for each dimension, the average score for each dimension ranges between 1 and 5. The developers reported a Cronbach's alpha of .916 for the entire questionnaire and for the subscales: Learning motivation (.801), planning and implementing (.816), self-monitoring (.785), and interpersonal communication (.765). In the study by Dortaj et al. (2019), the validity and reliability of the tool were confirmed. In this research, the Cronbach's alpha for this questionnaire was found to be .786.

Self- Regulation Learning Questionnaire (SRLQ): The Self-Regulated Learning Questionnaire (SRLQ) of students, contains 14 questions that was designed by Bouffard et al. (1995) in this scale, five options are considered for each item (strongly agree, agree, have no opinion, disagree and strongly disagree) scored from 5 to 1, respectively. Questions 5, 13 and 14 are reversely scored. Questions 1, 2, 4, 5, 13, 14 are related to the metacognitive component of self-regulation, questions 3, 7, 9, 10, 12 are related to the cognitive component and questions 6, 8, 11 are related to the motivational strategies. The total score ranged from 14 to70, that high score on this questionnaire indicates high self-regulation. Zimmerman and Kitsantas (2014) reported the overall predictive validity of this scale as desirable. They reported the reliability by Cronbach's

alpha method to be .86. In the Iranian version, the overall reliability coefficient of the questionnaire based on Cronbach's alpha was .71. The reliability of the cognitive strategies' subscale was .70 and the metacognitive subscale was .68. To determine its structure, the results of factor analysis showed that the correlation coefficient between the questions was appropriate and the measurement tool consisted of two factors. The value load related to the factors was acceptable and this tool was able to determine the self-regulatory variance by .52. The validity of the construct was also desirable (Kadivar, 2003). In the present study, Cronbach's alpha coefficient was obtained for this questionnaire at .92.

Results

The descriptive results of the study revealed that 54% of the sample were male and 46% were female, indicating that a larger proportion of the sample were male. Additionally, 71% of the participants were aged 24 or younger, 22.3% were aged between 25 and 30 years, and 6.7% were over 30 years old. Therefore, the majority of the sample was 24 years old or younger. In terms of academic level, 5% of the participants were at the associate degree level, 57% were at the Bachelor's degree, and 38% were pursuing a Master's degree or higher. Thus, the largest proportion of the sample was at the Bachelor's degree level. Based on the results, the skewness and kurtosis of all the variables fell within the -2 to +2. Therefore, the assumption of normality of the distributed data in the sample was supported. Table 1 presents the mean, standard deviation, and Pearson's correlations coefficient between the variables in the study.

Table 1. Descriptive Statistics for Research Variables

Research Variables	Mean	Standard Deviation	Minimum	Maximum
Self-directed learning	87.70	9.33	55	100
Learning motivation	25.67	3.21	15	30
Planning and implementing	25.66	3.07	15	30
Self-monitoring	17.40	2.02	6	20
Interpersonal Communication	17.22	2.65	7	20
Self-regulated learning	58/88	8.68	30	70
Cognitive	20.02	4.78	8	25
Motivational	12.46	2.11	6	15
Metacognitive	24.83	4.73	12	30
Problem-Solving	15.75	1.99	10	27
Helplessness	1.318	.812	.00	4
Problem solving control	3.148	.690	2	4
Creative style	3.300	.691	1.5	4
Confidence	3.195	.717	2	4
Avoidance style	1.583	1.097	.00	12
Approach style	3.205	.609	2	4

Table 1 shows the descriptive data including mean and standard deviation of variables and subscales. The results in Table 2 show correlation between SDL add its subscales and SRL its subscales with problem solving and its subscales.

Table 2. Pearson's Correlation Coefficient among the Research Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Self-Directed Learning	1															
Learning Motivation	0.720 **	1														
Planning and Implementing	0.773 **	0.578**	1													
Self-Monitoring	0. 626 **	0.357**	0.617**	1												
Interpersonal Communication	0.592 **	0.305**	0.426**	0.593**	1											
Self-Regulated Learning	0.249 **	0.215**	0.264**	0.300**	0.592**	1										
Cognitive	.577 **	.509**	.427**	.247**	.213**	.505**	1									
Motivational	.501 **	.382**	.402**	.362**	.299**	.641**	.658**	1								
Metacognitive	. 519 **	.450**	.394**	.236**	.197**	.560	.827**	.690**	1							
Problem-Solving	.501 **	.358**	.358**	.202**	.213	.473**	.469**	.358**	.502**	1						
Helplessness	.103	-.046**	-.048	-.102	.134*	-.090	.014	.045	.20	.097	1					

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Problem Solving Control	.376 **	.239**	.308**	.166**	.187**	.040	.321**	.262**	.345**	.585 **	.297**	1				
Creative Style	.481 **	.324**	.311**	.282**	.292**	.048	.352**	.293**	.392 **	.572 **	.261**	.572 **	1			
Confidence	.308 **	.237**	.220**	.212**	.163**	.138*	.369**	.263**	.358**	.488 **	.288 **	.488 **	.547**	1		
Avoidance Style	.080	.042	.033	-.052	-.001	.094	.082	.071	.091	.479 **	.045	0.479 **	.096	.160**	1	
Approach Style	.297 **	.239**	.215**	.131*	.140*	.043	.206**	.160**	.194**	.393 **	.125*	.393 **	.046	.008	.068	1

1=Self-directed learning, 2= Learning motivation, 3=Planning and implementing, 4=Self-monitoring, 5=Interpersonal communication, 6=Self-regulated learning, 7=Cognitive, 8=Motivational, 9= Metacognitive, 10=Problem-solving, 11=Helplessness, 12=Problem-solving control, 13=Creative style, 14=Confidence, 15=Avoidance style, 16=Approach style. * ($p<0.05$), **($p<0.001$).

Table 3 shows the normality data of the variables.

Table 3. Kolmogorov-Smirnov Test for Normality

Variable	Kolmogorov-Smirnov			Skewness & Kurtosis	
	Statistic	df	Sig.	Skewness	Kurtosis
Self-directed learning	.085	300	.061	-1.123	1.145
Learning motivation	.055	300	.198	-1.037	1.279
Planning and implementing	.057	300	.185	-.954	1.232
Self-monitoring	.062	300	.145	-1.036	1.927
Interpersonal communication	.067	300	.128	-1.378	1.753
Self-regulated learning	.091	300	.052	-.797	.263
Cognitive	.066	300	.131	-1.198	.665
Motivational	.050	300	.200	-.805	.141
Metacognitive	.048	300	.200	-.894	-.131
Problem-Solving	.079	300	.087	.528	1.84
Helplessness	.074	300	.099	.290	-.191
Problem solving control	.065	300	.138	-.261	-1.122
Creative style	.069	300	.115	-.652	-.547
Confidence	.070	300	.107	-.366	-1.199
Avoidance style	.041	300	.200	1.811	1.820
Approach style	.04	300	.200	-.346	-.666

According to Table 3 and regarding the normality of the data with Kolmogorov-Smirnov and the Skewness and Kurtosis, it can be concluded that the data were normal, and inferential analysis can be performed on the data.

To test the research model and calculate path coefficients, Structural Equation Modeling (SEM) was employed using AMOS. To determine the overall fit of the model, indicators were considered (Table 4).

Table 4. Final Models Fit Indicators

Fitness Index	X2/df	GFI	AGFI	CFI	NFI	IFI	TLI	RMSEA	PCLOSE
Value	2.79	.92	.90	.92	.90	.92	.903	.077	.001

The results of the analysis of the measurement models and the structural model are shown in Figure 2. Based on the information in Table 4, all fit indices fell within the acceptable range. The final modified model, all fit indices, including normalized chi-square ($\chi 2/df$), goodness of fit index(GFI), adjusted goodness of fit index (AGFI), comparative fit index (CFI), normalized fit index (NFI), incremental fit index (IFI), Tucker-Lewis index (TLI), and root mean square error approximation (RMSEA), indicate an acceptable fit of the final model to the data. The value of RMSEA is equal to .077, so this value is less than .1, which indicates that the mean of the squared errors of the model is suitable and the model is acceptable. Also, the chi-square value of the degree of freedom (2.79) is between 1 and 3, and the GFI, CFI, and NFI indices are almost equal or greater than .9, which shows that the research variable measurement model is appropriate. Table 5 shows weighted regression statistics and critical ratios of predictor variables.

Table 5.Weighted Regression Statistics and Critical Ratios for the Constructs

Direction			b	β	SE_b	t	P
Self-directed learning	→	Self-regulated learning	1.107	.547	.144	7.711	.001
Self-directed learning	→	Problem solving	. 035	.261	.013	2.815	.005
Self-regulated learning	→	Problem solving	.026	.384	.007	3.783	.001

Table 5 shows the prediction path values from the variable, based on the t-values obtained in the model. Overall, all the values are statistically significant, indicating meaningful predictions.

Table 6. Indirect Model Estimation using the Bootstrap Method

Variable	B	R2	lower limit	upper limit	Sig.
Self-directed learning on problem solving with self-regulated learning as the mediator	.210	.325	.144	.350	.002

Table 6 shows that the indirect paths, based on the standardized values (β), confirm the indirect effect of self-directed learning model on problem solving with self-regulated learning as the

mediator. This confirmation is according to the bootstrap estimation method and is significant at the specified level.

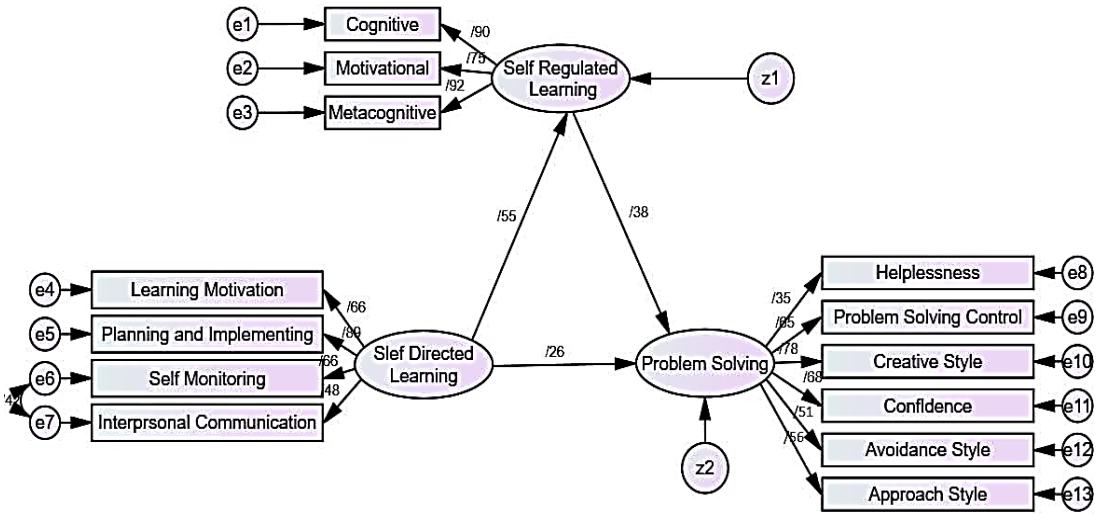

Figure 2. The Final Modified Model of the Mediating Role of Self-Regulated Learning in the Relationship between SDL and Problem Solving

Table 7 showed the results of the Preacher and Hayes add-in processor program in the regression analysis including the main and interactive effects of self-directed learning and gender in predicting problem solving are presented in.

Table 7. The Moderating Role of Gender in the Relationship between Self-Direction and Problem Solving

Predictors	R	R^2	F	Df1	Df2	sig	B	SE_b	t	sig
Gender	.509	.259	31.889	3	296	.001	.315	.202	1.563	.119
Self-directed learning							.106	.011	9.757	.001
							.014	.022	.65	.516
	ΔR^2	F	Df1	Df2	sig					
Self-directed learning×	.001	.422	1	269	.516					

According to the results obtained, the general model of predicting problem solving based on gender, self-direction and the interactive effect of gender and self-directed learning are significant (P<0.001). And gender was not a significant predictor of problem solving (B = .315, t = 1.563, P>0.05), Also, self-directed learning in the presence of gender was a significant predictor of problem solving (B = .106, t = 9.757, P<.05).The interactive effect of self-direction and gender in predicting problem solving is not significant (B = 0.014, t = 56, P>.05). Accordingly, gender does not play a moderating role in predicting problem solving based on SDL.

Discussion

The present study was conducted to investigate the relationship between SDL and problem-solving, with the mediating role of SRL and the moderating role of gender among university students at Al-Qadisiyah University in Iraq. The results of the study indicate that SDL has a direct effect on problem-solving, such that as SDL increases, problem-solving ability also improves. SDL, through the mediation of SRL, also has an indirect effect on problem-solving. This means that the increase in SRL further amplifies the effect of SDL on problem-solving. Gender did not moderate the relationship between SRL and problem-solving, as no significant differences between genders were found. Overall, the model demonstrated a good fit.

The results related to the direct effect of SDL on problem-solving are consistent with the studies by Tafaroji Gilavandani et al. (2021), Hwang and Oh (2021), and Leary et al. (2019). Gagne (1985) posits that problem-solving is a form of advanced learning, where individuals synthesize simpler issues to arrive at more complex solutions. Self-regulated learning in research is defined as the ability to be an independent individual in the learning process in terms of metacognitive, motivational, and behavioral perspectives (Lai & Hwang, 2016; van Gog et al., 2020). In other words, individuals use previously acquired knowledge to solve new problems. Therefore, problem-solving, as a higher-order cognitive activity, leads to the acquisition of new knowledge and skills (Saif, 2009). Problem-solving requires specific and purposeful strategies, through which individuals define problems, make decisions, implement strategies, and monitor their progress. These strategies include cognitive (understanding the problem or devising a plan) and metacognitive (explorations, reviews, or beliefs) strategies (Philipp, 2013; Schönfeld, 1985; cited in Root et al., 2021). Self-regulation strategies, encompassing both cognitive and metacognitive strategies, contribute to improved problem-solving skills. SDL, in particular, are more adept at problem-solving in order to achieve better learning outcomes. These learners actively engage in the learning process, taking initiative and relying on their intrinsic motivation, which influences problem-solving performance. This process, moving from an initial state toward a goal, requires effort and high internal motivation.

Results also showed that SDL positively influenced SRL, aligning with the findings from Hwang and Oh (2021) and Ebadi and Muqar (2021). SDL are characterized by self-management, meaning learners can identify their learning needs, set goals, and manage their time and energy. Additionally, self-control is another characteristic of SDL, enabling them to plan, execute, and evaluate their learning independently. Zimmerman (1986) noted that SRL actively engage in the learning process and strive for knowledge with less reliance on others. SDL also transforms the learner into an active participant, fostering a high level of engagement in the learning process. Consequently, the enhancement of self-awareness and self-control through SDL improves SRL in students.

Regarding the mediating role of SRL in the relationship between SDL and problem-solving, our findings are consistent with those of Hwang and Oh (2021), Al-Rasan (2017), Ebadi and Muqar (2021), Qhasemi et al. (2021), Tafaroji Gilavandani et al. (2021), and Van Gog et al. (2020), but not with those of Alghamdi et al. (2020) research. SRL refers to a process where an individual actively and independently sets learning goals, selects strategies to achieve those goals, and adjusts their learning as needed (Manzari Tovakoli, 2020). SRL are intrinsically motivated and employ learning strategies for cognitive regulation and effort, which ultimately improves their problem-solving capabilities. Metacognitive and cognitive strategies such as summarization, self-assessment, and rehearsal help individuals better understand and use information to solve problems. Additionally, SRL fosters self-awareness, which aids in identifying problems and finding solutions. This self-awareness, along with motivational strategies, helps learners persist through challenges.

The lack of moderation by gender in the relationship between SRL and problem-solving suggests that gender differences may stem from misperceptions of abilities, lack of readiness, or skill deficiencies that are influenced by cultural and social factors. These misperceptions are acquired and shaped by gender roles, stereotypes, educational opportunities, and expectations communicated through media, institutions, and society (Schwarzer, 2014). Previous research on gender differences in self-regulated learning and problem-solving has also yielded mixed results.

Conclusion

The findings of this study indicate that increasing SDL and SRL in university students can significantly enhance their problem-solving skills. SDL and SRL have similarities with respect to active engagement, goal-directed behavior, metacognitive skills, and intrinsic motivation. While SRL is usually considered as a learner characteristic, SDL is both a learner characteristic and a design feature of the learning environment. Further, SDL entails a student's more control over the learning environment and provides a crucial role for the learner in initiating a learning task. SDL dimensions consisting of four components, namely, learning motivation, planning and implementing, self-monitoring, and interpersonal communication, are used to identify a self-directed learner while SDL promotes motivated students to be responsible learners. In addition to being aware of learning strategies and using them effectively, self-regulated learners have the ability to maintain or increase their level of motivation to complete academic tasks even when faced with complex and difficult or monotonous and boring assignments, and they are better problem solvers.

Like all studies, the study had several limitations. One limitation was the use of a non-random convenience sampling method, which may have introduced bias and influenced the generalizability of the results. Additionally, the sample was not homogeneous in terms of academic discipline and

level, which may also impact the outcomes. Furthermore, this research was cross-sectional and conducted during the 2023-2024 academic year at Al-Qadisiyah University in Iraq. Therefore, caution is warranted when attempting to generalize the results to other time periods or locations. Based on these limitations, it is recommended that similar studies be conducted in different time periods and geographical locations, using cluster random sampling methods to include a more diverse range of participants with varying demographic and cultural backgrounds. Future research should also consider focusing on more homogeneous groups, such as students within a specific academic discipline or level, to obtain more accurate and precise results. Given the demonstrated impact of SDL and SDL on problem-solving abilities, it is advisable for educators and higher education stakeholders to implement strategies aimed at enhancing these skills among students. Incorporating self-regulation and problem-solving development into curriculum planning and academic interventions could further strengthen students' abilities to engage effectively with complex learning tasks and real-world challenges.

Author Contributions

All the authors participated in the design, implementation, and writing of all parts of this research.

Data Availability Statement

Data available on request from the authors.

Acknowledgements

We are grateful to all the people who have accompanied us in this research.

Ethical considerations

The authors avoided from data fabrication and falsification.

Funding

This research has not received any financial support.

Conflict of interest

No conflicts of interest declared.

References

Aghdar, A., Allipour, S., & Shehni Yeilagh, M. (2020). The relationship between executive functions and self-regulated academic learning regarding the mediating role of metacognition and working memory among university students. *Iranian Journal of Learning and Memory, 2*(8), 73-82. https://10.22034/iepa.2020.236019.1178

Alersan, S. R. (2017). Academic self-efficacy and problem-solving skills among Hail university students and the relationship between them in light of certain variables. *Journal of Educational & Psychological Sciences, 18*(1), 593-620. http://dx.doi.org/10.12785/jeps/180118

Alghamdi, A., Karpinski, A. C., Lepp, A., & Barkley, J. (2020). Online and face-to-face classroom multitasking and academic performance: Moderated mediation with self-efficacy for self-regulated learning and gender. *Computers in Human Behavior, 102*, 214-222. https://doi.org/10.1016/j.chb.2019.08.018

Almulla, M. A., & Al-Rahmi, W. M. (2023). Integrated social cognitive theory with learning input factors: The effects of problem-solving skills and critical thinking skills on learning performance sustainability. *Sustainability, 15*(5), 3978. https://doi.org/10.3390/su15053978

Arsanti, M., Zulaeha, I., & Subiyantoro, S. N. H. (2021). Tuntutan kompetensi 4C abad 21 dalam pendidikan di perguruan tinggi untuk menghadapi era society 5.0 [Demands for 21st century 4C competencies in higher education to face the era of society 5.0]. *Prosiding Seminar Nasional Pasca Sarjana*, 319–324.

Baars, M., Wijnia, L., & Paas, F. (2017). The association between motivations, affect, and self-regulated learning when solving problems. *Frontiers in Psychology, 8*, Article 1346. https://doi.org/10.3389/fpsyg.2017.01346

Babapour Kheyraldim, J., Rasoulzudeh Tabatabaei, K., Fathi Ashtiani, A., & Ezhehei, J. (2003). Study of the relationship between problem solving style and psychological well-being among university students. *Journal of Psychology, 7*(25), 3-16. SID. https://sid.ir/paper/54504/en.

Bouffard, T., Boisvert, J., Vezeau, C., & Larouche, C. (1995). The impact of goal orientation of self-regulation and performance among college students. *British Journal of Educational Psychology, 65*(3), 317–329. https://doi.org/10.1111/j.2044-8279.1995.tb01152.x

Broadbent, J. (2017). Comparing online and blended learner's self-regulated learning strategies and academic performance. *The Internet and Higher Education, 33*, 24–32. https://doi.org/10.1016/j.iheduc.2017.01.004

Brockett, R. G., & Hiemstra, R. (2018). *Self-direction in adult learning: Perspectives on theory, research and practice*. Routledge. https://doi.org/10.4324/9780429457319

Cadorin, L., Bressan, V., & Palese, A. (2017). Instruments evaluating the self-directed learning abilities among nursing students and nurses: a systematic review of psychometric properties. *BMC Medical Education, 17*(1), 229. https://doi.org/10.1186/s12909-017-1072-3

Canniford, L. J., & Fox-Young, S. (2015). Learning and assessing competence in reflective practice: Student evaluation of the relative value of aspects of an integrated, interactive reflective practice syllabus. *Collegian, 22*(3), 291-297. https://doi.org/10.1016/j.colegn.2014.04.003

Cassidy, T., & Long, C. (1996). Problem-solving style, stress and psychological illness: Development of a multifactorial measure. *The British journal of Clinical Psychology, 35*(2), 265–277. https://doi.org/10.1111/j.2044-8260.1996.tb01181.x

Cheng, S. F., Kuo, C. L., Lin, K. C., & Lee-Hsieh, J. (2010). Development and preliminary testing of a self-rating instrument to measure self-directed learning ability of nursing students. *International Journal of Nursing Studies, 47*(9), 1152–1158. https://doi.org/10.1016/j.ijnurstu.2010.02.002

Dortaj, F., Kianersi, F., Nasiripoor, S., & Mojabi, N. (2019). Analyzing the psychometric characteristics of self-directed learning scale among students. *Educational Measurement and Evaluation Studies, 9*(25), 91-112. https://doi.org/10.22034/emes.2019.35103

Ebadi, S., & Muqar, M. (1400). *The effect of self-directed learning on self-efficacy and academic self-regulation of students*. The 5th International Congress of Psychological Sciences and Education, Tehran. https://civilica.com/doc/1231870

Ebrahimi Zarandi, M., Manzari Tavakoli, H., Manzari Tavakoli, A. R., & Zeinaddini Meimand, Z. (2020). Priority-setting of effective components on the teaching-learning model with approach to improving problem-solving ability. *Iranian Journal of Learning and Memory, 3*(10), 17-23. https://10.22034/iepa.2020.244840.1202.

Faridian, K., Rezaei, A., & Misrabadi, M. (2021). The effectiveness of teaching self-regulation strategies on readiness for electronic learning and self-directed learning in students studying in virtual courses. *Education and Evaluation (Educational Sciences), 14*(55), 165-183. SID. https://sid.ir/paper/997817/fa.

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science, 18*(3), 233-239. https://doi.org/10.1111/j.1467-9280.2007.01882.x

Gagne, R. M. (1985). *The conditions of learning and theory of instruction* (Subsequent Edition). Wadsworth Pub Co.

Greene, J. A., Bernacki, M. L., & Hadwin, A. F. (2024). Self-regulation. *Handbook of educational Psychology*, 314-334.

Hwang, Y., & Oh, J. (2021). The relationship between self-directed learning and problem-solving ability: The mediating role of academic self-efficacy and self-regulated learning among nursing students. *International Journal of Environmental Research and Public Health, 18*(4), 1738. https://doi.org/10.3390/ijerph18041738

Jansen, R. S., Van Leeuwen, A., Janssen, J., Jak, S., & Kester, L. (2019). Self-regulated learning partially mediates the effect of self-regulated learning interventions on achievement in higher education: A meta-analysis. *Educational Research Review, 28*, 100292. https://doi.org/10.1016/j.edurev.2019.100292

Kadivar, P. (2003). The role of self-efficacy beliefs, self- regulation and intelligence in school performance among secondary school first grade students. *Psychological Achievements, 10*(2), 1-12. https:// 10.22055/psy.2003.17664

Kim, J. K., & Seo, J. T. (2021). Analysis of structural relationships among college freshmen's self-understanding, self-direction, learning competency, and problem-solving ability. *Journal of Human-centric Research in Humanities and Social Sciences, 2*(1), 25-34. https://dx.doi.org/10.21742/JHRHSS.2021.2.1.02

Kim, S. Y., Kim, S. J., & Lee, S. H. (2021). Effects of online learning on nursing students in South Korea during COVID-19. *International Journal of Environmental Research and Public Health, 18*(16), 8506. https://doi.org/10.3390/ijerph18168506

Lai, C., & Hwang, G. (2016). Computers and Education: A self-regulated flipped classroom approach to improving students 'learning performance in a mathematics course. *Computers & Education, 100,* 126–140. https://doi.org/10.1016/j.compedu. 2016.05.006

Leary, H., Walker, A., Lefler, M., & Kuo, Y. C. (2019). Self-directed learning in problem-based learning: A literature review. *The Wiley handbook of Problem-Based Learning*, 181-198.

Manzari Tavakoli, V. (2020). Meta-analysis of the relationship between self-regulated learning strategies with academic achievement. *Educational Psychology, 16*(58), 95-115. https://doi.org/10.22054/jep.2021.16535.1577

Morris, T.H. (2019). Self-directed learning: A fundamental competence in a rapidly changing world. *International Review of Education, 65* (4), 633-653. https://doi.org/10.1007/s11159-019-09793-2

Muhali, M. (2019). Pembelajaran Inovatif Abad Ke-21. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika, 3*(2), 25–50. https://doi.org/10.36312/e-saintika.v3i2.126

Nordin, N., Abd Halim, N., & Malik, M. (2016). Assessing readiness for self-directed learning among college students in the provision of higher learning institution. *Environment-Behavior Proceedings Journal, 1*(3), 91-101. https://doi.org/10.21834/e-bpj.v1i3.352

Olivier, J., & Wentworth, A. (2021). Self-directed learning at school and in higher education in Africa. In: Burgos, D., Olivier, J. (eds.), *Radical Solutions for Education in Afric*a. Lecture Notes in Educational Technology. Springer. https://doi.org/10.1007/978-981-16-4099-5_2

Qasemi, S., Azadi, M. M., Chagosaz, M., & Asgari, M. (2021). The effect of self-regulatory strategies training on problem-solving styles and self-directed learning for third grade male high school students. *Rooyesh, 10*(3), 101-110. http://dorl.net/dor/20.1001.1.2383353.1400.10.3.2.6

Rott, B., Specht, B., & Knipping, C. (2021). A descriptive phase model of problem-solving processes. *ZDM – Mathematics Education, 53*(4), 737-752. https://doi.org/10.1007/s11858-021-01244-3

Saif, A. A. (2024). *Modern educational psychology: psychology of learning and education*. Agah publishing.

Samadi, M. (1383). Examining the self-regulation of students' and parents' learning: studying the role of gender and academic performance. *Psychology and Educational Sciences, 34*(1), 157-175. SID. https://sid.ir/paper/55754/fa

Tafaroji Gilavandani, Z., Ahmadi, A., & Ahghar, G. (2021). Presenting a model of self-regulated learning strategies and its effect on problem-solving methods of high school students in Tehran, *Educational Administration Research Quarterly, 13*(1), 55-68. [In Persian]. http://www.Magiran.com/p2396726

Tekkol, İ. A., & Demirel, M. (2018). An investigation of self-directed learning skills of undergraduate students. *Frontiers in Psychology, 9*, 2324. https://doi.org/10.3389/fpsyg.2018.02324

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. Jossey-Bass/Wiley.

Van Gog, T., Hoogerheide, V., & van Harsel, M. (2020). The role of mental effort in fostering self-regulated learning with problem-solving tasks. *Educational Psychology Review, 32*(4), 1055–1072. https://doi.org/10.1007/s10648-020-09544-y

Yousefy, A., & Gordanshekan, M. (2011). A review on development of self-directed learning. *Iranian Journal of Medical Education, 10*(5 (Special Education)), 776-783. SID. https://sid.ir/paper/59034/en

Zarei, H. A., & Marandi, A. (2011). The relationship between learning strategies and problem -solving styles with educational achievement. Innovation in Management Education. *Journal of Modern Thoughts in Education, 6*(23), 109-128. SID. https://sid.ir/paper/154099/en

Zimmerman, B. J. (1986). Becoming a self-regulated learner: Which are the key sub processes. *Contemporary Educational Psychology, 11*, 1-25.

Zimmerman, B. J., & Kitsantas, A. (2014). Comparing students' self-discipline and self-regulation measures and their prediction of academic achievement. *Contemporary Educational Psychology, 39*(2), 145–155. https://doi.org/10.1016/j.cedpsych.2014.03.004