



Original Article



Relationship between Self-Directed Learning and Self-Regulated Learning in Problem-Based Learning

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ABSTRACT

Self-Directed Learning (SDL) was crucial for developing Self-Regulated Learning (SRL) skills, essential for success in Problem-Based Learning (PBL) settings. **Objective:** To explore the association between SDL and SRL, focusing on motivation, self-efficacy, and cognitive strategies. **Methods:** A longitudinal study design was conducted with 250 medical students in the PBL curriculum at Rawal Institute of Health Sciences Islamabad. Stratified random sampling ensured representation across academic performance levels. A structured survey assessed SDL (goal-setting, time management, and self-assessment) and SRL (motivation, self-efficacy, cognitive strategies, and behavioural regulation) using a 5-point Likert scale. Data were analysed using Chi-Square Goodness-of-Fit tests to explore distribution patterns, Bivariate Pearson correlation for relationships between SDL and SRL, and One-Way ANOVA to identify SRL differences across performance levels, with a significance threshold set at $p < 0.05$. **Results:** Significant engagement in SDL components, goal-setting and intrinsic motivation ($p = 0.001$), with moderate correlations between specific SDL skills and SRL outcomes. Time management showed a weak but significant correlation with cognitive strategies ($p = 0.03$), suggesting an impact on SRL behaviours. No significant differences were observed in SRL skills across academic performance levels ($p > 0.05$), indicating a uniform development of self-regulation skills regardless of prior achievement. High engagement in PBL discussions and peer collaboration further underlines these activities as central to fostering SDL and SRL. **Conclusion:** SDL in PBL shows a positive, however modest, impact on SRL outcome, management and self-assessment, which could further enhance SRL in medical education settings.

INTRODUCTION

In modern education, SDL has developed as an essential component for raising independence and resilience in students [1]. In medical education, SDL is highlighted as it aligns with the demands of continuous, lifelong learning in the healthcare profession [2, 3]. Within PBL environments, SDL encourages students to take responsibility for their education by actively identifying learning objectives, seeking resources, and evaluating their understanding [4]. This autonomy has been related to improved academic performance and increased adaptability, essential skills for future healthcare providers. PBL is structured as a real-

world clinical problem and provides students with a dynamic and interactive framework for relating theoretical knowledge to practical situations [5]. Contrasting traditional didactic teaching, PBL compels students to collaborate, communicate effectively, and think critically [6, 7]. SDL engagement allows students to set personal goals and take possession of their learning journey [8]. This autonomy improves comprehension and strengthens SRL skills as students develop methods to monitor and control their learning behaviour. SRL refers to students' ability to deliberately manage their learning through goal-setting,



self-monitoring, and self-reflection [9]. Vital components of SRL include motivation, self-efficacy, cognitive strategies, and behavioural regulation. These skills allow students to challenge complex and rigorous academic content with an organised approach [10]. In medical education, where vast amounts of knowledge must be retained and applied across diverse clinical scenarios, SRL provides a framework for students to process information and develop effective professional learning habits. Despite the theoretical alignment of SDL and SRL within PBL, observed evidence on the extent of their relationship remains limited. Previous studies have highlighted SDL as a foundational skill that can improve SRL [11-13]. Yet, the specific influence of SDL component goal-setting, time management, and self-assessment on SRL outcomes, motivation and self-efficacy were not well-documented. Additionally, there is interest in understanding how these skills may vary based on academic performance, as students with different achievement levels may exhibit varying degrees of SRL in response to SDL practices. This study aims to bridge this gap by examining the relationship between SDL skills and SRL outcomes within a PBL environment. By assessing SDL components alongside SRL variables like motivation, cognitive strategy used, and self-efficacy, the study seeks to determine how students' self-directed efforts translate into self-regulated behaviours. Furthermore, it explores whether SRL outcomes differ across academic performance levels, providing insight into how students of varying capabilities engage in SDL within PBL frameworks. The objective was to investigate the impact of SDL skills on SRL outcomes among medical students participating in PBL.

The study inspected components of SDL, goal-setting and time management in relation to SRL variables, including intrinsic motivation and cognitive strategies.

METHODS

This longitudinal study design, 6 months, 18th March 2024 – 18 September 2024 study investigated the relationship between SDL and SRL among students engaged in PBL. The study was conducted at the Rawal Institute of Health Sciences, Islamabad, involving medical students enrolled in the PBL curriculum during the academic year under study. The design allowed for a snapshot analysis of SDL and SRL characteristics within a defined population, focusing on their interplay across diverse academic performance levels. The sample size calculation was based on statistical power analysis to ensure reliable detection of moderate effect sizes. Using Cohen's guidelines for effect size determination ($d=0.5$), a significance level (α) of 0.05, and a desired statistical power of 0.80, the minimum required sample size was estimated to be 64 participants per group. For three groups (high, average, and low

academic performers), this yields a total sample size of 191 participants. To account for potential non-responses and strengthen the study findings' robustness, the sample size was increased to 250 participants. This exceeds the calculated minimum requirement and enhances the sample's representativeness. The study included students actively participating in a PBL course during the academic year were included in the study. Students who missed more than two sessions were excluded to ensure that participants had sufficient exposure to PBL activities. This criterion was applied to maintain data quality and ensure that reported SDL and SRL behaviors reflected consistent engagement with the PBL curriculum. Attendance data was carefully reviewed to minimise the potential for selection bias and ensure the exclusion criteria were applied uniformly across all performance groups. This step helped to ensure that the excluded students did not systematically differ in ways that would skew the analysis. By addressing attendance variability, the study maintained a balance between ensuring data reliability and reducing bias. Stratified random sampling was applied to ensure proportional representation across academic performance groups, thereby reducing bias and improving the generalizability of the results. Stratified random sampling was employed to ensure representation across academic performance groups (high, average, low), categorised based on students' grades. This approach facilitated meaningful comparisons of SRL outcomes across performance levels, contributing to a comprehensive analysis of how SDL impacts students differently depending on their academic standing. To minimise the impact of variability in PBL implementation across tutors and groups, several measures were taken to ensure consistency. All tutors received standardised guidelines detailing the objectives and processes for PBL sessions, ensuring alignment with the curriculum. Training sessions were conducted periodically to standardise facilitation techniques and reduce discrepancies in implementation. Students were randomly allocated to PBL groups to prevent systematic differences in group composition that could influence SDL and SRL outcomes. Despite these efforts, minor differences in facilitation styles and group dynamics may persist, and future studies could consider incorporating tutor or group as a random effect in statistical models to better account for such variability. Before data collection, the Institutional Review Board (IRB) of Rawal Institute of Health Sciences Islamabad Ref.no reviewed and approved the study. RIHS/IRB/18/2024 All participants provided informed consent. Measures were taken to handle data securely and ethically with institutional and research standards. The structured survey to assess SDL and SRL was adapted from validated instruments to ensure relevance to the student population.

SDL items focused on goal-setting, time management, and self-assessment, while SRL items addressed motivation, cognitive strategies, and behavioural regulation. The survey was grounded in established theoretical frameworks, including Zimmerman's self-regulated learning model and Knowles' principles of self-directed learning, ensuring alignment with established constructs. To validate the constructs of SDL and SRL, medical education specialists conducted expert reviews to ensure the survey items were clear, contextually relevant, and aligned with theoretical frameworks. Pilot testing with a representative sample of the target population further validated reliability, achieving Cronbach's alpha values exceeding 0.7 for all constructs, which indicates good internal consistency. While exploratory factor analysis (EFA) was not performed to confirm the statistical distinction between SDL and SRL constructs, the conceptual alignment and expert validation provide confidence in the survey's ability to measure these domains. Future studies could employ EFA to statistically confirm the theoretical distinction between SDL and SRL, further strengthening the survey's construct validity. Composite scores for SDL and SRL were calculated to reflect an aggregate measure of students' engagement and skills in these domains. Each SDL component (goal-setting, time management, and self-assessment) and SRL variable (motivation, cognitive strategies, and behavioural regulation) was assessed using multiple survey items rated on a 5-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). Each item contributed equally to its respective component score. The goal-setting component included several items, and the responses for these items were summed and then averaged to calculate the composite score for goal-setting. All items within a component were weighted equally, ensuring a proportional representation of all aspects of that component in the composite score. Differential weighting was not applied as no evidence suggested variable importance among items. An overall SDL score was calculated by averaging the composite scores of its three components: goal-setting, time management, and self-assessment. Similarly, an overall SRL score was calculated by averaging the composite scores of its variables: motivation, cognitive strategies, and behavioural regulation. High scores in individual components or overall scores indicated more substantial proficiency and engagement in the respective SDL or SRL skill areas. These scores provided a quantitative basis for analysing the relationships between SDL and SRL and comparing outcomes across different academic performance levels. The survey was administered at the end of the academic term to ensure students' complete exposure to PBL activities. The inclusion criteria were: (1) students actively participate in a

PBL course within the academic year of the study, and (2) students with complete attendance for the sessions under investigation. The exclusion criteria included (1) students who had missed more than two PBL sessions, as their engagement levels might not accurately reflect SDL practices, and (2) students who were not participating in PBL as part of their curriculum. This careful selection ensured the data's consistency and relevance, enhancing the findings' reliability. The data were collected through a structured survey administered at the end of the academic term. The survey was planned to assess SDL skills (goal-setting, time management, self-assessment) and SRL outcomes (motivation, cognitive strategies, and behavioural regulation). For apprehension SDL skills, students responded to items related to their engagement in goal-setting, time management, and self-assessment during PBL sessions. The survey assessed intrinsic motivation, self-efficacy, cognitive strategies, and behavioural regulation for SRL. Answers were collected on a '5-point Likert scale', ranging from "Strongly Disagree" (1) to "Strongly Agree" (5), allowing for a quantitative measure of both SDL and SRL skills. Data were analysed using SPSS version 25.0. To appropriately handle the ordinal nature of Likert-scale responses, ordinal logistic regression was applied to assess the relationship between SDL and SRL components. This method is particularly suited for Likert-scale data as it accounts for the ordinal structure while providing insights into the probability of specific response categories. Additionally, Bivariate Pearson Correlation and One-Way ANOVA were employed to explore relationships and group differences where appropriate. Results were interpreted using p-values and effect sizes to ensure practical and statistical significance. The analysis began with the Chi-Square Goodness-of-Fit test, which assessed whether the observed SDL and SRL skill responses significantly deviated from the expected distribution. This test was particularly suitable for categorical and ordinal data, responses collected on a Likert scale, to determine whether certain SDL or SRL skills were more prevalent among participants. Then, to examine relationships between SDL and SRL skills, a Bivariate Pearson Correlation was conducted. Alongside the correlation coefficients (r) and their associated p-values, effect sizes were calculated to determine the practical significance of the observed relationships. Effect sizes were interpreted based on Cohen's benchmarks ($r=0.1$: small, $r=0.3$: medium, $r=0.5$: large). This analysis identified significant associations between SDL practices and SRL outcomes, with statistically significant correlations at p-values below 0.05. A significant correlation between goal-setting and intrinsic motivation would suggest that students who set clear goals also experience higher motivation in their PBL

work. Finally, a One-Way Analysis of Variance (ANOVA) was used to explore differences in SRL scores across academic performance groups (High, Average, Low). Alongside p-values, partial eta squared (η^2) was calculated as an effect size measure for ANOVA, with thresholds of 0.01 (small), 0.06 (medium), and 0.14 (large). This test compared mean scores of SRL skills among the three groups, with significant differences highlighted by p-values below 0.05. Post hoc analyses were performed where significant differences were found to determine which specific performance groups differed. Still, there was no significant association of ANOVA, so no post hoc was performed.

RESULTS

Frequency distribution of SDL and SRL skills, goal-setting and intrinsic motivation showed significant engagement among students ($p = 0.001$), indicating strong adoption in PBL settings. Time management received high disagreement ($p = 0.001$), suggesting it was challenging for students. Self-assessment showed mixed engagement ($p = 0.023$), indicating room for improvement. Non-significant results in learning strategy selection and behavioural regulation suggest variability in these areas, with inconsistent adoption.

Table 1: Frequency Distribution of SDL and SRL Skills

Variables	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	p-value
Goal-Setting	-	-	-	76	174	0.001
Time Management	41	209	-	-	-	0.001
Self-Assessment	-	-	107	-	143	0.023
Learning Strategy Selection	-	-	-	132	118	0.37
Motivation (Intrinsic)	72	-	-	-	178	0.001
Motivation (Extrinsic)	-	-	121	129	-	0.613
Self-Efficacy	-	-	-	160	90	0.001
Cognitive Strategies	110	-	-	-	140	0.05
Behavioural Regulation	-	-	122	-	128	0.7

Table 2 showed that engagement in PBL sessions, discussions, and collaboration with peers were highly rated ($p = 0.001$), indicating active student involvement in these core PBL activities. Application of critical thinking showed a non-significant result ($p = 0.3$), reflecting varied engagement. Seeking clarification was significantly engaged ($p = 0.004$), highlighting students' tendency to seek understanding.

Table 2: Engagement in PBL Sessions

PBL Component	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	p-value
Participation in Discussions	-	-	-	103	147	0.001
Collaboration with Peers	66	-	-	-	184	0.001
Application of Critical Thinking	-	-	133	117	-	0.3
Seeking Clarification	-	-	-	148	102	0.004

Table 3 showed a weak but significant positive correlation between time management and cognitive strategies ($r=0.134, p=0.03$, small effect size). No significant correlations were observed for goal-setting, motivation, or self-efficacy ($r < 0.1$, negligible effect sizes).

Table 3: Correlation between SDL and SRL Skills

SRL Variables	SDL Variable Goal-Setting	Time Management	Self-Assessment	Learning Strategy
Motivation	$r = 0.02$, $p = 10.73$	$r = 0.052$, $p = 0.41$	$r = 0.075$, $p = 0.23$	$r = -0.086$, $p = 0.173$
Self-Efficacy	$r = 0.025$, $p = 0.69$	$r = -0.050$, $p = 0.42$	$r = -0.025$, $p = 0.69$	$r = -0.37$, $p = 0.55$
Cognitive Strategies	$r = 0.065$, $p = 0.30$	$r = 0.134$, $p = 0.03$	$r = 0.114$, $p = 0.07$	$r = 0.037$, $p = 0.55$
Behavioural Regulation	$r = 0.058$, $p = 0.36$	$r = -0.069$, $p = 0.27$	$r = -0.060$, $p = 0.34$	$r = -0.028$, $p = 0.664$

In table 4 differences in self-regulated learning by academic performance: No significant differences in SRL scores were observed across academic performance groups ($p > 0.05$), but the effect size ($\eta^2 = 0.03$) suggests a small practical difference in behavioral regulation."

Table 4: Difference in Self-Regulated Learning by Academic Performance

Academic Performance Group	Motivation (Mean)	Self-Efficacy (Mean)	Cognitive Strategies (Mean)	Behavioral Regulation (Mean)	N	p-value
High Performers	3.75	4.36	4.65	3.88	96	0.635
Average Performers	4.01	4.29	4.53	4.01	73	0.234
Low Performers	3.81	4.42	4.57	3.96	81	0.314
Total					250	-

DISCUSSION

The findings from this study reveal the relationship between SDL and SRL skills, with specific SDL components of time management showing weak yet significant correlations with specific SRL outcomes. This supports previous research that underscores time management as a vital skill in enhancing learning efficiency and promoting self-regulation [14]. Although SDL and SRL were conceptually aligned, the modest strength of correlations indicates that SDL skills alone may not fully account for SRL outcomes, suggesting that other factors, personal motivation and external influences, could play a role in shaping SRL within PBL contexts [15, 16]. Several

moderating or mediating factors may influence the weak correlations observed between SDL and SRL components. Intrinsic motivation, for instance, could serve as a mediator, enhancing the impact of SDL practices like goal-setting and self-assessment on SRL outcomes, cognitive strategies and behavioural regulation. Students with higher intrinsic motivation may be more likely to effectively translate SDL efforts into self-regulated learning behaviours, suggesting that motivation could amplify this relationship. External support from peers, tutors, and the structured PBL environment could also act as a moderator, either strengthening or dampening the connection between SDL and SRL. Students receiving consistent feedback and encouragement in collaborative settings may exhibit better integration of SDL practices into SRL outcomes. Conversely, such support's absence might limit SDL practices' effectiveness, leading to weaker correlations. These findings highlight the complexity of the SDL-SRL relationship and suggest that the interplay of personal and external factors may significantly shape these dynamics. Future studies could explore these moderating and mediating factors in greater depth, using advanced statistical techniques like mediation or moderation analysis to better understand their roles in shaping SDL and SRL relationships. The significance of intrinsic motivation and self-efficacy among students engaged in PBL highlights the role of internal drivers in self-regulation. Intrinsic motivation, as indicated by high engagement levels, aligns with prior studies showing that intrinsically motivated students tend to exhibit stronger SRL behaviours [17, 18]. The findings support that PBL naturally fosters intrinsic motivation by providing a collaborative, real-world context that engages students beyond grades or external rewards. While several SDL and SRL components showed significant correlations, some variables, such as learning strategy selection and behavioural regulation, did not yield statistically significant results. This lack of significance may be attributed to several factors. One potential explanation is the inherent variability in how students interpret and engage with these constructs. Behavioural regulation, for instance, may depend heavily on external factors like tutor guidance or group dynamics, which were not explicitly controlled or measured in this study. Similarly, learning strategy selection might be less apparent in a PBL setting, where collaborative and problem-solving tasks take precedence over individually selected strategies. Measurement limitations may also have contributed to these findings. The survey items for learning strategy selection and behavioural regulation, while adapted from validated instruments, may not have fully captured the nuances of these constructs in a PBL context. Additionally, the

reliance on self-reported data could have introduced response biases, particularly for variables that require introspective assessments and behavioural regulation. Analytical limitations, including using longitudinal study design correlations for these variables, may have also constrained the ability to detect subtle relationships. Future research should consider employing longitudinal designs, refining measurement tools, and incorporating complementary data sources, such as tutor observations or peer evaluations, to capture the complexity of these constructs better. This study's weak correlations and insignificant results may partly be attributed to methodological limitations. One potential issue is the survey design, which relied on self-reported responses. While validated instruments were used, self-report surveys are prone to biases such as social desirability and recall errors, which may have affected the accuracy of responses for constructs like time management and behavioural regulation. Another limitation could be the limited scope of the survey items in capturing the full complexity of SDL and SRL behaviours within the PBL context. For example, learning strategy selection may require more nuanced or context-specific items to fully reflect students' experiences and practices in a collaborative environment. From an analytical perspective, using longitudinal study design methods, Pearson Correlation and ANOVA may have restricted the ability to detect dynamic or complex relationships between SDL and SRL components. Advanced statistical techniques, such as structural equation modelling (SEM), could better capture the interplay between these constructs, while longitudinal designs could reveal causal relationships over time. Addressing these methodological challenges in future research could enhance the robustness and validity of findings, providing deeper insights into the dynamics of SDL and SRL in PBL settings. This environment allows for cultivating curiosity and persistence, crucial for maintaining SRL behaviours over time. Self-efficacy, another key component of SRL, was also positively perceived among participants, aligning with the notion that confidence in one's ability enhances learning effectiveness. Despite high levels of engagement in collaborative activities during PBL sessions, students reported weaker time management skills. This apparent contradiction can be interpreted using established theoretical frameworks. According to Zimmerman's self-regulated learning model, collaboration in PBL fosters external regulation through peer feedback and shared goals, which can overshadow individual time management responsibilities. Similarly, Knowles' principles of self-directed learning suggest that while PBL encourages autonomy, its collaborative structure may lead to a

diffusion of personal responsibility for managing time effectively. This imbalance could reflect the challenge of balancing shared group tasks with individual responsibilities within a structured PBL environment. Students may prioritise immediate group-based demands, such as collaboration and discussion, over self-regulation activities like time management. These findings highlight a potential area for intervention, such as incorporating explicit time management training into PBL sessions to complement the collaborative focus. Future research could further explore this dynamic to better integrate individual and group regulatory processes in PBL settings. Prior studies have linked self-efficacy to academic resilience, suggesting that students who believe in their capabilities are likelier to persist through challenges and employ effective cognitive strategies [19, 20]. In this study, the high levels of self-efficacy observed underscore the role of PBL in building student confidence, as it encourages active problem-solving and provides immediate feedback through peer and tutor interactions. No significant differences in SRL skills across academic performance levels provide comprehension into the consistency of SRL behaviours among 'high, average, and low performers in PBL settings'. This finding suggests that PBL may serve as an aligning environment where all students, regardless of prior performance, have the opportunity to develop SRL skills. The lack of significant differences may also be attributed to the relative homogeneity of SRL development across academic performance groups. All students were exposed to the same PBL curriculum, which likely provided a consistent framework for fostering SRL skills, reducing observable group-level variations. Additionally, while the longitudinal design captured changes over time, the six-month duration might not have been sufficient to reveal more pronounced differences. Small effect sizes ($\eta^2=0.03$) indicated that minor variations in behavioural regulation exist but did not reach statistical significance due to the subtle nature of these changes. Future studies with longer durations or larger group-specific sample sizes could better uncover these differences. Studies have shown that PBL can reduce performance differences by providing structured yet flexible opportunities for students to engage in SDL and SRL practices'. This study highlighted the potential of PBL as an outline for integrating SDL and SRL. PBL fosters vital SRL skills for academic and professional success by providing an environment that inspires goal-setting, active learning, and collaboration. It suggests that SDL contributes to SRL, and there was scope for educational strategies that directly support students in managing time and self-assessing effectively. These insights may help future curriculum development in medical education, highlighting SDL and SRL necessary for

developing independent, competent healthcare practitioners. A key limitation of this study is its reliance on self-reported data to measure SDL and SRL. While validated instruments were used, self-reported responses are inherently subjective and may be influenced by social desirability bias. Incorporating multiple data sources is recommended to strengthen the validity of results in future research. Peer evaluations could provide an external perspective on students' collaborative behaviours and self-regulation in group settings, complementing self-reported data. Similarly, tutor feedback would offer valuable insights into students' engagement, time management, and goal-setting behaviours observed during PBL sessions. Academic performance metrics, grades, task completion rates, or attendance could serve as objective indicators of SDL and SRL outcomes. These additional data sources would allow for triangulation, reducing bias and enhancing the robustness of findings. Implementing such approaches in future studies could offer a more comprehensive understanding of SDL and SRL dynamics within PBL contexts. To address this limitation, future studies could incorporate complementary data collection methods. Observational assessments during PBL sessions can provide direct insights into students' behaviours related to goal-setting, time management, and collaboration. Additionally, performance-based metrics, such as academic grades or task completion efficiency, could be objective measures of SDL and SRL outcomes. Furthermore, peer and tutor feedback could offer a third perspective, strengthening the validity of the findings through data triangulation. Implementing these approaches in future research will reduce reliance on self-reported measures and enhance the robustness of conclusions drawn.

CONCLUSIONS

This study highlighted the association of SDL and SRL within problem-based learning PBL environments. While SDL skills, goal-setting and time management correlate modestly with SRL outcomes, motivation and cognitive strategies, these skills alone were insufficient predictors of self-regulation. High engagement in PBL activities, discussions, and peer collaboration develops intrinsic motivation and self-efficacy, supporting SRL across varied academic performance levels. PBL thus emerges as a promising approach for developing autonomous and self-regulated learners necessary for the medical profession.

Authors Contribution

Conceptualisation: WUN

Methodology: KA, SN, NG

Formal analysis: NG

Writing, review and editing: WUN, KA, SN, ZA, NG

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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