Received: 19 June 2023 | Revised: 13 October 2023 | Accepted: 23 October 2023

DOI: 10.1002/hsr2.1689

ORIGINAL RESEARCH

Health Science Reports Open Access WILEY

Understanding the interplay of self-regulated learning strategies in medical education: A cross-sectional structural equation modeling study

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Abstract

Background and Aims: Although previous studies have investigated self-regulated learning strategies, a holistic study has not been conducted on note-taking, environmental structuring, self-evaluation, and self-consequence strategies among medical students. The current study focused on the relationships between these four self-regulated learning strategies in a medical context.

Methods: A conceptual model of the four strategies was developed, supported by the relevant literature. This cross-sectional study used an electronic structured questionnaire. The sample consisted of 557 medical undergraduates. The data were analysed using confirmatory factor analysis and structural equation modeling to investigate the hypothetical model.

Results: The conceptual model fits the data well. All relationships between the strategies were significantly positive, except for a regression between environmental structuring and self-evaluation, which was nonsignificant. Self-evaluation strategies represented the highest mean, whereas self-consequence strategies represented the lowest.

Conclusion: The findings of this study have implications for medical students, their teachers, and their universities regarding ways to enhance learners' regulated learning strategies. Future research should be conducted to develop additional statistical and comparison models for use in experimental studies and longitudinal investigations.

KEYWORDS

environmental structuring, note-taking, self-consequences, self-evaluation, self-regulated learning strategies

1 | INTRODUCTION

Self-regulated learning (SRL) is a process in which learners engage in specific cognitive, metacognitive, behavioral, motivational, and emotional activities to achieve their personal goals in learning.[1,2] It is a process that involves setting goals, selecting and employing appropriate learning strategies, and reflecting on one's progress and performance.[3] SRL empowers individuals to take ownership of their learning journeys. It promotes autonomy, adaptability, and resilience in facing challenges.[4–6] It is a valuable skill for learners

of all ages and can be applied in various educational and professional settings.[7–10]

SRL plays a crucial role in the education of medical students, as it empowers them to actively engage in their learning process, enhance their academic performance, achieve their goals, and develop lifelong learning skills.[11–13] SRL equips medical students with the necessary tools to navigate medical education's demanding and complex nature and prepares them for future careers as healthcare professionals.[11]

The SRL process consists of three phases: forethought, performance, and self-reflection, defined by Zimmerman.[14] In the forethought phase, learners set their goals, develop a plan, and activate their prior knowledge and strategies to guide their learning. The performance phase involves the actual execution of the learning activities, where learners employ various SRL strategies to facilitate their learning process. The self-reflection phase consists of evaluating one's performance, assessing progress towards the goals, and adjusting for future learning. Note-taking (NT) and environmental structuring (ES) are two behavioral SRL strategies used during the performance phase, whereas self-consequences (SC) and self-evaluation (SE) are other SRL strategies associated with the motivational aspects of learning and are part of the self-reflection phase.[15–17] These four strategies are important for medical students in pursuing academic excellence, knowledge acquisition, and professional development in medicine.[11,18,19]

In detail, NT is a fundamental strategy that allows medical students to actively engage with lecture materials, textbooks, and other learning resources.[20,21] By systematically recording and organizing critical information, medical students enhance their comprehension, retention, and recall of complex medical concepts.[22,23] Effective note-taking promotes active learning, facilitates critical thinking, and enables students to create personalized study materials as valuable references for future review and examination preparation.[24,25]

ES is essential for medical students to create an optimal learning environment conducive to concentration, focus, and productivity.[26] The demanding nature of medical education often requires students to dedicate long hours to studying and research.[27] Medical students can enhance their ability to concentrate, process information, and engage in deep learning by organizing their study space, minimizing distractions, and optimizing their physical and digital resources.[28,29] A well-structured environment promotes effective time management, reduces procrastination, and cultivates a sense of discipline and commitment to study routines.[30] Lin and Bigenho[31] found that NT and ES strategies correlate. In particular, they discovered that NT on paper resulted in better memory retention and higher performance in a word recall task than on a laptop.

SE is another critical SRL strategy that empowers medical students to reflect on their learning progress, identify strengths and weaknesses, and make informed adjustments to their study strategies.[32,33] By self-reflection, students can assess their understanding of medical concepts, critically analyse their performance in exams or assessments, and identify areas that require further focus or remediation.[34,35] Self-evaluation enables students to monitor their learning outcomes, identify gaps in knowledge, seek additional resources or guidance, and continually improve their competence[36,37] and hence mastery in the medical field.

Finally, SC is vital in motivating medical students to achieve their learning goals and complete their academic tasks effectively.[38,39] By setting up a system of rewards and consequences, medical students can create incentives that encourage discipline, persistence, and dedication to their studies.[40,41] Students can reinforce positive study habits, sustain motivation, and boost their self-efficacy by establishing meaningful rewards for accomplishing specific milestones or meeting deadlines.[42] Self-consequences provide a sense of accountability, helping students overcome challenges and maintain a proactive approach to their medical education.[43]

However, there is a notable gap in the existing literature concerning the comprehensive investigation of NT, ES, SE, and SC as SRL strategies, specifically among medical students. While previous studies have examined various SRL strategies in this population, such as goal setting and planning,[44] help-seeking behaviors,[45] and information-seeking behaviors,[46] none have specifically focused on the four aforementioned strategies within a medical context. Therefore, this study aims to address this gap by concentrating solely on these four SRL strategies in a medical student cohort.

1.1 | The current study

To better understand the relationships among NT, ES, SE, and SC among medical students, a conceptual model (Figure 1) was developed. Each connection in the model represents a hypothesis that is supported by relevant literature. The following hypotheses are proposed:

H1. NT is related to ES. This hypothesis is supported by the study conducted by Lin and Bigenho,[31] which offered valuable insights into how note-taking and environmental structuring interact with each other. It sheds light on how different media environments can impact note-taking practices and, in turn, influence memory outcomes. This emphasises the importance of considering environmental factors when developing effective self-regulated learning strategies.

H2. There is a relationship between NT and SE. This aligns with the analysis conducted by Lai and Hwang[47] study. In their review of selected journal publications from 2010 to 2020, the researchers underscored the importance of NT and reviewing records as crucial SRL

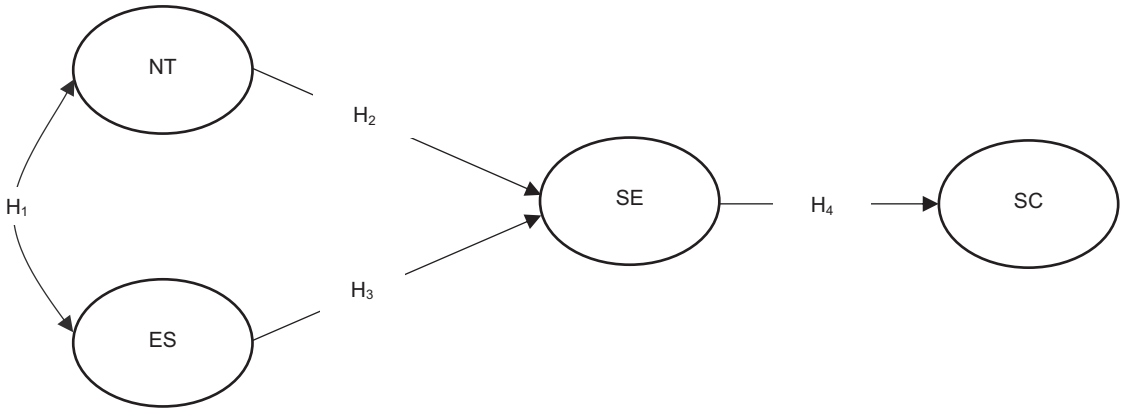

FIGURE 1 A conceptual model of the relationships between note-taking (NT), environmental structuring (ES), self-evaluation (SE), and self-consequences (SC). The ovals represent latent variables, the solid arrows represent direct empirical relationships between the variables, and the double-headed arrows represent correlation between the variables.

strategies. These strategies were found to have a significant relationship with learners' cognitive, affective, and behavioral outcomes, including SE. The findings highlighted the positive impact of NT and reviewing records on learners' ability to assess their own performance and make necessary adjustments in the process of self-regulation.

H3. ES is related to SE. In their comparative analysis of conventional and blended learning in undergraduate studies, Onah et al.[48] discovered that self-regulated students clearly understood their learning environment needs. They recognized the importance of creating a tidy, silent space with minimal distractions to optimize their learning experience. This finding highlights the relationship between self-evaluation and environmental structuring. By evaluating their learning processes, these students could identify the need for an effective learning environment and take appropriate measures to create an environment conducive to self-directed and self-regulated learning.

H4. There is a relationship between SE and SC. This hypothesis is consistent with the findings of Onah et al.,[48] who showed that SE is related to the implementation of SC. In their study, an undergraduate student mentioned rewarding herself as a means of self-consequence when she achieved her goals. This highlights the potential connection between SE standards and the adoption of SC. The student's self-rewarding behavior indicates a conscious assessment of her performance and a deliberate use of positive reinforcement to reinforce her learning outcomes.

The theoretical model suggests that all the links among the four strategies (NT, ES, SE, and SC) are positive, as shown in Figure 1.

2 | MATERIALS AND METHODS

2.1 | Setting

The study was conducted with undergraduate students in the Medical College of King Saud University. The medical degree program spans 7 years, consisting of 14 semesters, including two internships. Admission to the medical program is highly competitive, with only students who achieve high marks on three preuniversity tests (secondary school test, national general aptitude test, and national academic achievement test for scientific specialization) being accepted.[49–51]

During the first academic year, known as the Common First Year, students undertake various subjects to develop their academic skills, such as English, computers, and academic writing. Additionally, students are classified into six tracks (health, nursing, sciences, business, humanities, and social sciences) based on their performance on the three preuniversity tests. Students in the health track typically have the highest marks among their peers and are expected to achieve top scores throughout their undergraduate studies.[49]

Investigating the associations among NT, ES, SE, and SC, specifically among medical students, is particularly important for several reasons.

First, medical students face a demanding and prolonged educational journey, comprising numerous tests, exams, and challenges over an extended period.[52] It is crucial to understand how medical students employ these SRL strategies to excel academically, manage their study commitments effectively, and thrive in a highly competitive and rigorous academic environment. Second, medical students are considered self-regulated learners, demonstrating autonomy and taking responsibility for their learning process.[11,19]

They actively set goals, plan, monitor their progress, and make necessary adjustments.[53] Investigating the specific SRL strategies utilised by medical students allows for a better understanding of how they navigate the complexities of their medical education, develop effective study routines, and cultivate lifelong learning skills essential for their future careers as healthcare professionals.[54] Moreover, the selection process for admission to the medical program at KSU ensures that students possess exceptional academic abilities and have demonstrated a solid commitment to their education.[49,55] Exploring the associations among NT, ES, SE, and SC, specifically among medical students, provides valuable insights into the strategies employed by high-achieving individuals motivated to excel academically and contribute to the field of medicine.

This current study can provide valuable insights into the learning strategies employed by high-achieving medical students, inform educational practices, and contribute to improving medical education and student outcomes.

2.2 | Questionnaire

Al Sahan's[49] questionnaire was used to collect data about SRL strategies, self-efficacy, and motivation, and it was initially designed for Saudi undergraduates from different colleges and fields. Each strategy was treated as a latent variable and represented by three items, except for NT, which consisted of four items. Participants responded to the items using a 5-point Likert scale, ranging from "strongly disagree = 1" to "strongly agree = 5." The latent variables were computed by taking the mean of the respective items. The reliability of the factors was assessed by McDonald's omega coefficients (ω), yielding the following values: NT $\omega = 0.979$, ES $\omega = 0.976$, SE $\omega = 0.981$, and SC $\omega = 0.971$. However, these reliability coefficients for the current study will be discussed further in the Results section.

2.3 | Participants

The participants for this study were selected randomly using their students' identification (ID) numbers from an Excel (xlsx.) file provided by the university. The selection process involved running the function = RAND() on the file. A total of 700 medical undergraduates—regardless of gender—were chosen as the initial sample and received the questionnaire via email. However, only 639 participants responded to the survey. There were exclusion criteria. To ensure data quality, 82 participants (12.8% of the initial sample) were excluded from the analysis due to having more than 20% missing data or demonstrating a consistent response pattern for more than eight sequential items and being identified as outliers. The final sample used for analysis consisted of 557 participants, with M_{age} of 21.02 and SD_{age} of 2.98.

In addition, a post hoc power analysis was conducted to determine the minimum sample size "n" required for the adopted analysis—structural equation modeling (SEM) analysis (more details in Section 2.5). The adopted formula for this is $n \geq 10k$, as discussed by Kline,[56] where "n" represents the sample size, and "k" corresponds to the total number of model parameters to be estimated. In this context, "k" encompassed 13-factor loadings + four regression paths + 13 error variances. This means n should be $\geq 10 \times 30$ (i.e., $n \geq 300$). Hence, the current sample size (557) is adequate for the statistical analysis.

2.4 | Data collection

The questionnaire was created using Google Forms and distributed on November 15, 2022 to the participants through their university-provided email addresses, which the university administration organized in an Excel (xlsx) file. Approval was obtained from the Research Ethics Committee at the university (ethics approval number KSU-HE-23-831). All participants in the study were adults aged 18 years or older, and they provided their oral consent to participate in this study.

2.5 | Data analysis

Descriptive statistical analysis was performed using SPSS Version 26 to calculate the variables' mean (M) and standard deviation (SD). A two-tailed test defined statistical significance as a $p < 0.05$. McDonald's omega coefficient (ω) was used to assess the reliability of the measures, as it estimates the extent to which items measure a single latent factor.[57]

To test the theoretical model, two analytical steps were followed: (1) confirmatory factor analysis (CFA) was employed to assess the measurement model and (2) structural equation modeling (SEM) was utilised to examine the structural model. The model acceptance criteria included having at least three indicators (items) for each latent variable (factor), fixing cross-loadings to zero, ensuring that factor loadings were statistically significant (t-ratio ≥ 1.96), and 95% confidence interval.[58] The standardized factor loadings were expected to be at least 0.30.[59] Acceptable model fit was determined based on the following criteria: nonsignificant χ^2, comparative fit index (CFI) ≥ 0.90, Tucker-Lewis index (TLI) ≥ 0.90, root mean square error of approximation (RMSEA) ≤ 0.06, and standardized root mean square residual (SRMR) ≤ 0.08.[58] It is important to note that the current survey sample is relatively large ($N = 557$); and because χ^2 is highly sensitive to large sample size, it might be significant; however, it is not a reason in itself to reject any of the models as long as the other indices are within the acceptable cut-offs criteria.[56,58]

Full information maximum likelihood with robust standard error estimation was employed. The software Mplus (version 8.4)[60] was used to perform the CFA and SEM analyses.

3 | RESULTS

3.1 | Measurement model

The initial measurement model did not fit the data satisfactorily, particularly in terms of the TLI and RMSEA values (CFI = 0.910;

TLI = 0.868; RMSEA [90% confidence interval] = 0.063 [0.053–0.074]; SRMR = 0.050). A modification was made to improve the model fit by freeing a parameter between item 1 and item 4 in the NT factor based on a high modification index (MI = 63.209). This adjustment led to improved model fit indices (CFI = 0.931; TLI = 0.896; RMSEA [90% confidence interval] = 0.056 [0.045–0.067]; SRMR = 0.046), but further improvement was required to meet the TLI cut-off value. Further examination of the modification indices revealed another parameter that needed to be freed between two items (12 and 13) in the SC factor, with a meaningful modification index (MI = 115.258). With this additional modification, the final measurement model demonstrated satisfactory goodness of fit (χ^2[df] = 131.813[52], $p < 0.001$; CFI = 0.942; TLI = 0.911; RMSEA [90% confidence interval] = 0.052 [0.041–0.063]; SRMR = 0.044). The standardized factor loadings ranged from 0.365 to 0.700, all significant at $p < 0.001$ (Figure 2).

Regarding the descriptive statistics, the highest mean observed was in the SE factor ($m = 4.14$, SD = 0.59) and the lowest mean was in the SC factor ($m = 3.43$, SD = 0.70). Then, the correlation between the factors was investigated, showing that $r = 0.179$, $p < 0.01$ between NT an SE; $r = 0.320$, $p < 0.01$ between NT and SE; $r = 0.093$, $p < 0.05$ between ES and SE; and $r = 0.364$, $p < 0.01$ between SE and SC.

The reliability (ω) estimates for the factors were all accepted. These findings confirm the model's goodness of fit, factor loadings, correlations, and scale reliability. These findings are promising to move forward to investigate the structural model. For detailed statistics on the measurement model, including descriptive statistics of the factors and their items, refer to Table 1.

3.2 | Structural model

The results of the measurement model were found to be significant. Subsequently, the structural model (and the

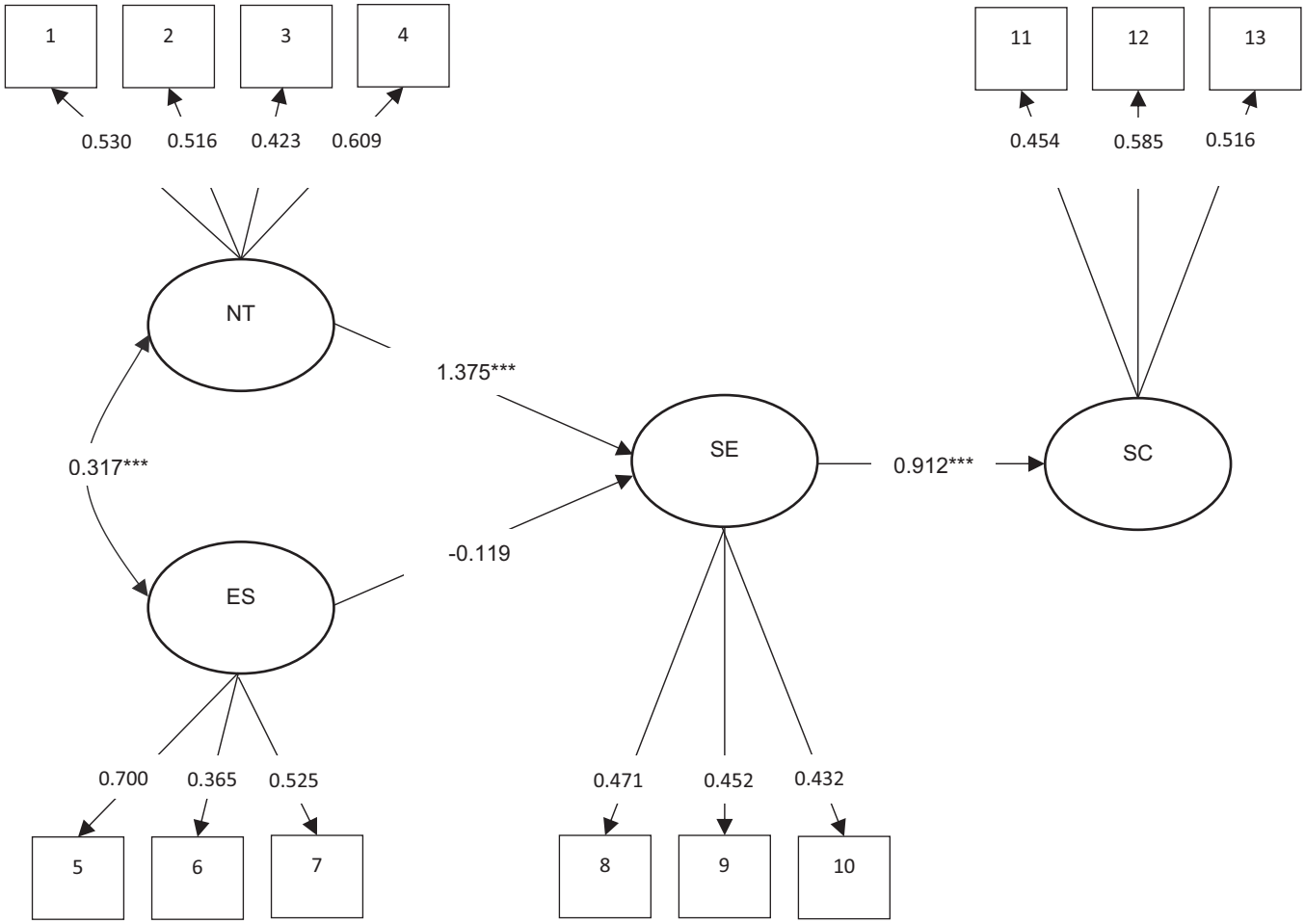

FIGURE 2 Model estimates (standardized) indicator loadings for observed variables, that is, the measurement model, and estimates (standardized) relationships between the latent variables, that is, the structural model) of note-taking (NT), environmental structuring (ES), self-evaluation (SE), and self-consequences (SC). ***$p < 0.001$ (otherwise it is not significant); and all the indicator loadings are significant at $p < 0.001$. Ovals represent latent variables, solid arrows represent direct empirical relationships between the variables, and double-headed arrows represent correlations between the variables.

TABLE 1 Descriptive statistics and the measurement model indicator loadings for observed variables.

Latent and observed variables		*M* (SD)	Measurement model loadings (standardized)	SE	95% CI
NT (*M* = 4.00; SD = 0.66; ω = 0.990)					
1	I write down important information in a notebook or on loose sheets.	4.24 (0.94)	0.530***	0.036	0.460–0.601
2	I write down important notes in the book itself or on sticky notes and then stick them into the book.	4.17 (0.91)	0.516***	0.036	0.445–0.587
3	I make sure that I summarize the topics I study in points.	3.97 (0.92)	0.423***	0.044	0.338–0.509
4	I make sure that I summarize the topics I study in drawings and mind maps.	3.62 (1.05)	0.609***	0.043	0.524–0.694
ES (*M* = 3.91; SD = 0.66; ω = 0.986)					
5	I make sure that I study for a test in a comfortable and quiet place.	4.25 (0.98)	0.700***	0.080	0.543–0.857
6	I know exactly which room or place I should study in for a test	4.33 (0.95)	0.365***	0.065	0.237–0.493
7	I use the resource room or the library at the university when I study.	3.16 (1.34)	0.525***	0.055	0.418–0.631
SE (*M* = 4.14; SD = 0.65; ω = 0.987)					
8	I understand that my academic level is excellent because I understand the subjects very well.	3.88 (0.90)	0.471***	0.043	0.387–0.555
9	I make enough effort to achieve my academic goals.	4.20 (0.91)	0.452***	0.040	0.373–0.531
10	I make sure that I know the mistakes I make in a test so that I do not repeat them.	4.36 (0.81)	0.432***	0.052	0.331–0.534
SC (*M* = 3.43; *SD* = 0.80; ω = 0.982)					
11	I reward myself for the effort I make, not for the marks I get.	2.65 (1.17)	0.454***	0.051	0.354–0.554
12	I punish myself if I do not get the mark I am aiming for; e.g., I don't use my mobile for a day, or I don't meet my friends on the weekend.	2.62 (1.31)	0.585***	0.044	0.499–0.671
13	If I do not get the mark I am aiming for, I punish myself by studying more and more.	3.39 (1.29)	0.516***	0.040	0.437–0.596

Abbreviations: CI, confidence interval; ES, environmental structuring; M, mean; NT, note-taking; SC, self-consequences; SD, standard deviation; SE, standard error; ω, McDonald's omega coefficients.

***$p < 0.001$.

TABLE 2 Path analysis and correlation of the structural model.

Path	β	SE	Bias corrected CI	
			2.5%	97.5%
NT < > ES	0.317***	0.078	0.748	1.038
NT > SE	1.375***	0.079	1.252	2.142
ES > SE	−0.119	0.088	−0.157	0.027
SE > SC	0.912***	0.045	0.748	1.038

Abbreviations: CI, confidence interval; ES, environmental structuring; NT, note-taking; SC, self-consequences; SE, self-evaluation; SE, standard error; β, beta.

***$p < 0.001$.

measurement model), depicted in Figure 2, was assessed. The model demonstrated a good fit to the data ($\chi^2[df] = 131.813[52]$, $p < 0.001$; CFI = 0.939; TLI = 0.909; RMSEA [90% confidence interval] = 0.052 [0.041–0.064]; SRMR = 0.046). Most of the links between the factors were significantly positive at $p < 0.001$. Notably, the correlation between NT and ES was moderate ($r = 0.317$), supporting H_1. The strongest association was observed between NT and SE ($\beta = 1.375$), thereby supporting H_2. The connection between SE and SC ($\beta = 0.912$) also supported H_4. However, unexpectedly, the correlation between ES and SE was insignificant, leading to the rejection of H_3. Further details regarding these results can be found in Table 2.

4 | DISCUSSION

This research examined the interrelationships among four SRL strategies, namely NT, ES, SE, and SC, within the context of Saudi medical undergraduates. A structured questionnaire was employed. The results indicated that SE had the highest mean score among the four strategies. Furthermore, the findings demonstrated significant positive relationships between most of the SRL strategies, except for the insignificant relationship observed between ES and SE.

The anticipated results of this study were to confirm the correlation between NT and ES. According to Zimmerman,[17] both NT and ES are categorized as behavioral SRL strategies and are part of the performance phase of SRL subprocesses.[14] This finding is consistent with Lin and Bigenho's[31] experimental study results, as the researchers provided insights into the interplay between note-taking and environmental structuring. It highlighted the influence of different media environments on note-taking practices and subsequent memory outcomes, emphasising the potential significance of environmental factors in shaping effective SRL strategies. However, the authors acknowledged two limitations in their research. Firstly, the relationship was investigated in a nonreal situation, warranting further examination in an authentic learning environment. Second, they could not identify additional interaction effects or connections between these SRL strategies and others.

The present study, on the other hand, collected data from students in a natural learning environment and expanded the investigation to include two additional learning strategies. Moreover, it explored the simultaneous relationships between all four strategies using SEM as a statistical estimation procedure. These findings highlight the importance of teaching medical students NT skills and enhancing this learning strategy.[61] NT can be facilitated through various methods, such as pen and paper, smart devices, and available apps, with the guidance and support of instructors and teachers with expertise in effective NT methods. Additionally, medical schools or colleges are responsible for providing medical students with a comfortable and structured learning environment that promotes their learning.[62,63]

The significant direct relationship observed between NT and SE aligns with the findings of Lai and Hwang.[47] Their study highlighted the importance of NT and reviewing records as crucial SRL strategies that impact learners' cognitive, affective, and behavioral outcomes, including SE. Medical undergraduates, who are conscious of their academic goals, regularly assess their performance and adapt their SRL strategies accordingly. NT plays a significant role in organizing study materials and facilitating effective review processes.[64] Self-regulated learners know what to write, how, and where to write it.[65] They may utilise various methods such as highlighting essential ideas in specific colors, creating mind maps, using A4 size paper, or employing colored stickers, all of which reflect their SE.[49,66]

The unexpected insignificant regression between ES and SE is consistent with the findings of.[67] Their study identified significant associations between six SRL strategies and medical students' evaluations, but ES was not among the strategies found to be substantial. This could be attributed to the fact that the medical students in their study did not require extensive efforts to structure their learning environments. Most of their courses were conducted in well-organized and structured halls and clinical laboratories. ES may encompass more than just studying in a quiet room in medical education, as indicated by the ES items in Table 1.

Among the latent variables, the results indicated that SE had the highest mean. This finding aligns with the demanding nature of medical education, characterized by a heavy academic workload, complex and extensive content, and limited leisure time.[32,33,68] Given these challenges, SE is a critical self-regulated responsibility for medical students. It enables them to cope effectively with the academic burden and develop and maintain their professional competencies.[69,70] Moreover, SE is a metacognitive process relevant to medical students' professional development.[71] It involves planning, goal setting, and overcoming challenges, skills vital for their future careers.[64,70] Sebesta and Speth[67] also found a correlation between SE and improved exam grades in the medical field. To enhance their SE learning strategies, medical students can engage in self-reflection by asking themselves questions about their learning styles, strengths, and weaknesses. By being objective and honest in their responses, they can identify areas for improvement and implement strategies to enhance their SE skills.[64] Practising self-awareness and self-assessment can contribute to developing effective SE strategies among medical students.

Despite SC having the lowest mean among the latent variables, a positive relationship was observed between SC and SE. This finding aligns with Zimmerman's categorization of SC and SE as belonging to the motivational category.[17] Foong, Bashir[64] highlighted that medical students might engage in self-rewarding behaviors upon achieving their academic or study targets, such as allocating time for social activities and pursuing hobbies. These self-rewards are perceived as a means of appreciation and serve to prevent feelings of burnout associated with extensive studying.

However, it should be noted that SC is not necessarily a requirement for high-achieving students, as attaining excellent grades may already be a common occurrence for them. Al Sahan[49] found that undergraduates with consistently high grades did not need to reward or punish themselves based on their performance. In her study, one student expressed, “I don't reward or punish myself… because I want the results [the excellent results] to be something normal to me… I want to get used to getting excellent marks.” In the context of medical education, it is plausible that medical students, regardless of their grade performance, may not prioritize self-reward or punishment. Nevertheless, they may utilise SC as self-motivation to sustain their efforts and enhance their academic performance.

This study highlights the intricate interplay between key SRL strategies among Saudi medical undergraduates. While the specific relationships between note-taking, environmental structuring, self-evaluation, and self-consequences were explored, it is crucial to recognize the broader implications for SRL in medical education. Our findings underscore the importance of nurturing SRL skills among medical students to excel academically and navigate the

demanding nature of their education and future professional responsibilities. Medical educators and institutions should consider incorporating explicit instruction and support for these SRL strategies into their curricula to enhance students' ability to set goals, employ effective learning strategies, self-evaluate, and stay motivated. As medical education evolves, cultivating self-regulated learners equipped with these skills becomes increasingly essential for producing competent and resilient healthcare professionals.

4.1 | Strengths, limitations, and future studies

This study has several strengths and limitations. Regarding the strengths, This study collected data from students in a natural learning environment, enhancing the findings' external validity. This means the results are more applicable to the actual experiences of Saudi medical undergraduates. The study extended the investigation to include four SRL strategies, providing a comprehensive understanding of how these strategies interrelate in the context of medical education. This expansion goes beyond previous studies, which may have focused on a narrower set of SRL strategies. Structural Equation Modeling (SEM) as a statistical estimation procedure is a robust approach to simultaneously examining relationships between multiple variables. It adds credibility to the findings and allows a deeper understanding of the interplay between the SRL strategies.

Concerning the limitations and future studies, the data collected for this study were cross-sectional, which means that causal relationships between the latent variables or the trajectories of each factor over time cannot be inferred. Future research could benefit from conducting experimental studies to examine the causal influence of one SRL strategy on another, such as investigating the impact of SE on SC. Additionally, longitudinal studies could shed light on how SE evolves and changes during the undergraduate period. The analysis conducted in this study did not include group comparisons, such as gender differences. Previous research has suggested that Saudi female students tend to achieve higher academic performance than male students.[72] Therefore, conducting comparative studies based on gender using techniques like multigroup confirmatory factor analysis followed by structural equation modeling could enhance our understanding of the factors under investigation. Another limitation of this study is that it focused solely on medical undergraduates from a specific university. The findings may not be generalisable to students in other fields or colleges. SRL strategies could vary across disciplines, and medical education's specific demands and learning environments may influence the relationships between these strategies. Including students from diverse fields and colleges in future studies would provide a more comprehensive understanding of SRL strategies across various academic domains.

In sum, addressing these limitations in future studies would contribute to a more nuanced understanding of the relationships and dynamics of SRL strategies among undergraduates.

4.2 | Practical implications

The following insights offer practical guidance for educators and institutions in medical education and may facilitate the preparation of students for success in their academic journey and future healthcare careers.

- The significant relationship between NT and SE suggests that medical educators should consider emphasising and teaching practical note-taking skills to students. This can be facilitated through various methods and technologies, with guidance from instructors experienced in NT methods.
- The high mean score of SE highlights its importance in the demanding field of medical education. Educators should encourage self-evaluation practices among students, helping them develop critical metacognitive skills. This can include setting goals, reflecting on their learning styles, and identifying areas for improvement.
- While SC had the lowest mean, it was related to SE. Medical educators should acknowledge that students may engage in self-rewarding behaviors as motivation. Understanding the role of SC can help educators provide support and guidance to prevent burnout and maintain motivation.

5 | CONCLUSION

This study examined the use of SRL strategies among medical students and investigated the relationships between these strategies. The findings revealed that the sampled medical students employed SRL strategies such as NT, ES, SE, and SC. The analysis demonstrated significant positive relationships among all four strategies, except for the lack of a significant relationship between ES and SE. These findings have important implications for medical students and educators in universities and educational institutions, emphasising the need to enhance and promote effective SRL strategies.

For medical students, understanding and utilising SRL strategies can be instrumental in improving their learning outcomes and coping with the demands of their academic workload. Teachers and educational institutions play a crucial role in supporting students by providing guidance and creating conducive learning environments that facilitate the development and implementation of SRL strategies.

To further advance the field, future research should consider developing statistical and comparison models to better understand the relationships among different SRL strategies. Experimental studies can be conducted to explore the causal influences between strategies, such as investigating the impact of SE on SC. Longitudinal investigations would also be valuable in examining how SRL strategies evolve and change over the undergraduate period.

Overall, this study contributes to the existing literature on SRL strategies among medical students and provides insights into their usage and relationships. By promoting effective SRL strategies' development and application, students and educators can enhance

the learning experience and academic performance in the medical field.

AUTHOR CONTRIBUTIONS

Eman Faisal: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; software; supervision; validation; visualization; writing—original draft; writing—review and editing.

ACKNOWLEDGMENTS

I want to express my heartfelt gratitude to my husband for his unwavering support throughout this research endeavor. Special thanks are extended to the medical students who willingly participated in this study.

CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

TRANSPARENCY STATEMENT

The lead author Eman Faisal affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

DATA AVAILABILITY STATEMENT

All the relevant data are in the manuscript. The data supporting this study's findings are available from the corresponding author upon reasonable request. All authors have read and approved the final version of the manuscript. The corresponding author had full access to all of the data in this study and took complete responsibility for the integrity of the data and the accuracy of the data analysis.

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How to cite this article: Faisal E. Understanding the interplay of self-regulated learning strategies in medical education: a cross-sectional structural equation modeling study. *Health Sci Rep*. 2023;6:e1689. doi:10.1002/hsr2.1689