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Fostering Self-Directed Learning Capacity in Medical Students through Learning Online Course

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Abstract

The past decade has witnessed a significant transition from traditional offline education to online learning. Online learners are expected to succeed through self-directed learning (SDL). However, the connection between SDL capacity and online courses remains inadequately explored. This study investigated the impact of a two-month online Human Parasitology course on the SDL capacity of undergraduate medical students. A single-group interventional study was performed, and statistical analyses were conducted to estimate student satisfaction levels as well as changes in students' SDL level, SDL capacity, and learning habits throughout the online learning experience. Following online learning, significant enhancements were observed in various dimensions of SDL capacities among 82 students. The proportion of students exhibiting high levels of SDL increased by nearly 11% by the end of the course. The course was proved to be well-designed in each section of lessons, resulting in approximately 94% of students expressing satisfaction. Additionally, students' learning habits were significantly reshaped, leading to a preference for fragmented time management. The findings of this study demonstrate a positive impact of online courses on strengthening students' SDL capacities while also highlighting areas for potential improvement in course design. These insights are valuable for the development of online courses and the promotion of SDL skills in the field of medical education.

Keywords

Self-Directed Learning, Online Course, Medical Education, Online Learning,

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Online Learner

1. Introduction

Over the past decade, there has been a significant transition from traditional classroom instructions to online education, particularly among undergraduate and graduate students (Jin & Kim, 2024; Min Young Doo, 2023: pp. 1-20). The global COVID-19 pandemic dramatically accelerated this shift, compelling educators and students to adapt rapidly to the online learning environment (Zhu et al., 2024: pp. 2787-2803). Recent data indicates consistent and ongoing movement towards online education (Daniel, 2013; Min Young Doo, 2023: pp. 1-20; Xu, Duan, Padua, & Li, 2022). As anticipated, medical education has evolved in accordance with these trends. Students majoring in clinical medicine or other healthcare professions are actively engaging in online courses to complement their conventional academic pursuits (Pei & Wu, 2019; Ricotta et al., 2022: pp. 530-540).

However, online courses may present challenges for medical students, as the interactive dynamics among learners, educators, and course materials can sometimes diminish the sense of accomplishment (Muilenburg & Berge, 2005: pp. 29-48; Rosemary Kim et al., 2013: pp. 150-160). Shortcomings in learning initiative, time management, organizational skills, collaborative learning, and information processing can contribute to suboptimal learning outcomes. Students often struggle to manage their time efficiently, comply with structured learning schedules, and monitor their progress throughout the course. Previous studies have identified several obstacles to successful online learning (Isabel Elaine Allen, 2005). Therefore, the learning capacities of medical students are vital not only to their immediate learning outcomes but also to their long-term career development.

Self-directed learning (SDL), as articulated by adult education expert Malcolm Knowles, is a learner-centered educational philosophy in which students are empowered to take charge of their learning outcomes, with educators serving as facilitators (Knowles, 1975). SDL is an essential cognitive skill that boosts student self-efficacy and is particularly important for medical students aspiring to become lifelong learners (Ricotta et al., 2022: pp. 530-540). In this model, students must proactively identify their learning needs, set goals, select resources, develop plans, and evaluate outcomes. Educators can leverage innovative online tools and techniques to engage students and foster their SDL, potentially reducing the need for face-to-face instruction. The accessibility of educational materials in online courses, the user-friendly design of the online interface, and the flexibility regarding learning location and personal schedules often encourage students to complete courses effectively with minimal educator involvement. The technical proficiency of online courses facilitates the creation of a conducive learning environment, which in turn promotes SDL skills and encourages proactive engagement and independent thinking. However, our understanding of how online education

impacts learning outcomes and enhances students' SDL capacities remains limited. While some research links SDL to improved learning outcomes (Si, 2022: pp. 145-154), other studies raise concerns about the reliability of SDL as a predictor of success in online learning environments (Rosemary Kim et al., 2013: pp. 150-160). Thus, gaining a comprehensive understanding of medical students' SDL behaviors, the influence of online courses, and the dynamic interactions between students and online courses is essential.

Despite the growing significance of SDL in online education, there remains a dearth of studies investigating the relationship between SDL capacity and high-quality online courses. In this study, we established a two-month online course in Human Parasitology for medical students at the Peking Union Medical College, where students participated through SDL. We aim to assess the students' satisfaction with the course and to evaluate improvements in their SDL capacities over the learning process. The assessment data will provide insight into the interactions between the course content and students' SDL capacities, as well as how these factors impact learning satisfaction in the context of online education. Ultimately, our findings may enhance student engagement in online learning and better prepare them for the challenges of modern medical practice.

2. Materials and Methods

2.1. The Online Course

A two-month online course in Human Parasitology at the Peking Union Medical College was developed prior to this study. This course consisted of nine task-oriented lessons covering various aspects of human parasitology. Each lesson was structured into seven sections: syllabus, teaching videos, textbook and courseware, homework, discussion topics, formative assessment quizzes, and a question-and-answer segment. Each lesson, treated as an individual task, was designed to be completed within one week to foster learners' adherence to a disciplined learning schedule. Throughout each lesson, students had the flexibility to organize their learning activities. Educators were responsible for engaging students through online interactions, as well as for monitoring, guiding, and enhancing the students' learning experience.

2.2. Instruments

We referred to a SDL capacity rating scale developed by Chinese scholars (Ling et al., 2021: pp. 1080-1084; Suzhen, 2014: pp. 1034-1037). This scale was specifically designed to evaluate the SDL competencies of medical students and exhibited a high level of internal consistency, with a Cronbach's α of 0.93. In this study, we made minor modifications to the original scale to meet our requirements (**Table 1**). The scale consisted of 18 items divided into four dimensions: learning motivation or attitudes, self-planning and implementation, learning cooperation and coordination, and capabilities of processing online learning resources. Each item was measured with a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The total score of the scale spanned from 18 to 90, allowing for

the classification into three subranges from low to high scores to represent different SDL capacity levels. Students scoring above 66 were classified as possessing high levels of SDL proficiency, whereas those scoring below 42 were designated as demonstrating low SDL competency. Students falling between these two thresholds were recognized as exhibiting middle levels of SDL capabilities. In addition, a questionnaire featuring six items was designed to collect students' background information (e.g., age, gender, online learning experience, gains in online learning, daily online vs offline learning, and online learning habits), along with another six items (e.g., the satisfaction with overall online course, learning materials, quizzes, discussion sections, online homework, and question & answer segments) to assess their satisfaction with the learning process and course delivery, as shown in Table 2. These items were integrated into comprehensive questionnaires administered at both the beginning and end of the course.

Table 1. Modified SDL capacity rating scale.

Dimension	Item
Learning motivation	1. I believe that studying medicine is meaningful. Despite its challenges, I enjoy it.
	2. I believe test scores reflect my personal learning to some extent. Previous senior students in the Human Parasitology course had an average score exceeding 83, and I aim to achieve at least this score through diligent study.
	3. I have taken several interesting professional courses and intend to spend more time on these courses.
	4. I often feel that time flies when I am learning through the online teaching platform.
	5. I find it easier to focus and complete the learning tasks when taking online classes.
Self-management	6. I strive to accumulate professional knowledge daily while enrolled in an online course.
	7. I log in to the online course platform or search for information to review the course content.
	8. I am not very nervous before the final exam because I have confidence in my abilities.
	9. With the online learning platform, I actively log in to complete the required tasks.
	10. I can articulate what I have learned in the past week.
	11. I adjust my learning progress and method based on assessing my learning effect in time.
	12. After the offline learning sessions, I review what I have just learned through online resources.
Collaboration	13. I share my opinions and insights through online platforms.
	14. When I encounter professional challenges not addressed in the course, I seek answers through the online teaching platform.
Information processing	15. I find it easy to communicate with my classmates on the online teaching platform.
	16. When encountering a problem, I am able to find satisfactory solutions online.
	17. I can quickly identify the shortcomings of the online teaching platform, such as missing content I need.
	18. The lack of online teaching resources has driven me to seek alternative ways to meet my learning needs.

Table 2. Questionnaire items on students' background and satisfaction.

Category	Item
Students' background	1. What is your age? ○20, ○21, ○22 2. What is your gender? ○Male, ○Female 3. How long have you been involved in online learning? ○Less than 1 year, ○More than 1 year 4. How does your knowledge gained in online courses compare to that gained in offline courses? ○Less than in offline course, ○More than in offline course 5. What percentage of your daily online activities are dedicated to learning? ○More than 50%, ○Less than 50% 6. Which of the following learning habits do you prefer during online learning? ○I prefer using precisely planned time, ○ I prefer using randomly fragmented time
Students' satisfaction	1. I was satisfied with the overall online course during the learning. ○1, ○2, ○3, ○4, ○5 2. I was satisfied with the learning materials during the learning. ○1, ○2, ○3, ○4, ○5 3. I was satisfied with the quizzes during the learning. ○1, ○2, ○3, ○4, ○5 4. I was satisfied with the discussion sections during the learning. ○1, ○2, ○3, ○4, ○5 5. I was satisfied with the online homework assignments given during the learning. ○1, ○2, ○3, ○4, ○5 6. I was satisfied with the question-and-answer sessions during the learning. ○1, ○2, ○3, ○4, ○5

2.3. Participants and Procedure

A single-group interventional study was conducted between September 2023 and January 2024. The participants included third-year undergraduate medical students. Following the implementation of questionnaires and data collection, a comprehensive analysis of the pre- and post-learning process was performed, aiming to illuminate students' satisfaction with the learning process and the effects of the course on their SDL capacities. To assess learning outcomes, a final exam was administered upon course completion. Each participant's performance was scored in a 100-scaled test, comparable to the assessment method employed for students who completed the same course via traditional offline learning in 2022. To ensure consistency and reliability, the scores were graded independently by the same two faculty members for two consecutive years. The study was supervised and approved by the Teacher Development Center of Peking Union Medical College. The participants were enrolled voluntarily, and data were collected anonymously to ensure privacy.

2.4. Data Analysis

Initially, 82 medical students were enrolled in this study. Following data filtration, 80 pre-course feedbacks and 74 post-course responses were deemed valid for subsequent analysis. Descriptive statistics were performed to determine the means

and standard deviations for all variables. Differences in SDL capacity scores and test scores of students from two different years were estimated by an unpaired Student's t-test. Differences in the levels of students' SDL capacities and their learning behaviors throughout the course were examined using Chi-square tests. Statistical analyses were conducted using IBM SPSS version 27.0 (IBM Corp., Armonk, USA), and a *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Students' Characteristics

The majority of participants were 21 years old (n = 80, 97.56%), with a slight gender imbalance, as the sample comprised relatively more females (n = 49, 59.76%) compared to males (n = 33, 40.24%). Most students (n = 74, 92.24%) reported having participated in online learning for over a year and expressed a tendency to perceive greater benefits from online learning compared to offline courses. Furthermore, a notable proportion of students (n = 44, 65.85%) indicated that they dedicated approximately half of their daily online activities to knowledge pursuits before the start of this course. Their learning habits revealed a slight preference for planned study time rather than randomly allocated time for online learning (Table 3). These findings suggest significant engagement in online learning, reflecting the students' fundamental adaptability and potential for SDL.

Table 3. Overview of participants' general information.

Variables		Numbers (%)
Age		
	20	1 (1.21)
	21	80 (97.56)
	22	1 (1.21)
Gender		
	Male	33 (40.24)
	Female	49 (59.76)
Online learning experience		
	Less than 1 year	8 (9.76)
	More than 1 year	74 (92.24)
Gains in online learning		
	Less than in offline courses	31 (37.80)
	More than in offline courses	51 (62.20)
Daily online vs. offline learning		
	Less than 50%	38 (34.15)
	More than 50%	44 (65.85)
Online learning habit		
	Precisely planned time	49 (59.76)
	Randomly fragmented time	33 (40.24)

3.2. Student's Satisfaction with the Online Course

A satisfaction survey using a questionnaire was conducted at the end of the online course. Six items were included to assess the students' satisfaction with the course overall and each section of the lessons. Pertaining to the overall impression, the majority of students reported high satisfaction (n = 59, 73.75%) or satisfaction (n = 16, 20%) during the course (Figure 1a). Regarding the individual lesson section, the data indicated broad levels of high satisfaction or satisfaction among students (Figures 1b-f). A few students expressed dissatisfaction with the survey (Figures 1c-f). These satisfaction results demonstrate that the online course was well-structured and provided sufficient learning content to cater to diverse learning styles and paces. The structured learning path, coupled with the flexibility to revisit lessons and complete assignments at their own convenience, positively contributed to their learning behaviors. Therefore, most students found the online course to be highly beneficial, significantly enhancing their understanding of the subjects in the course.

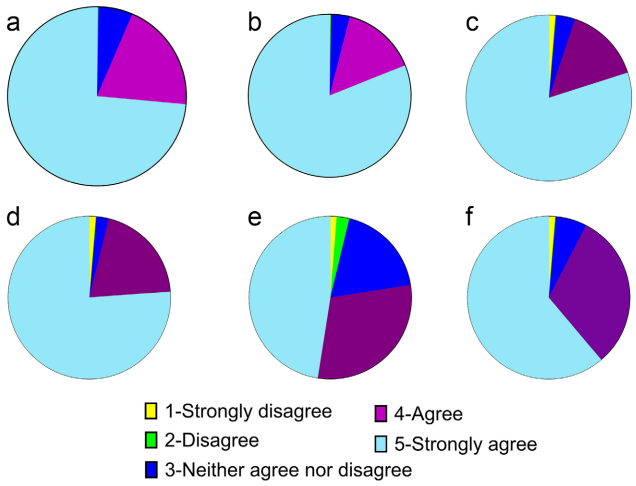

Figure 1. Distribution of student satisfaction regarding the overall online course and its individual section. Satisfaction levels were measured using a 5-point Likert scale, ranging from strongly agree to strongly disagree. Survey items were phrased as "I was satisfied with the * during the learning". The asterisk (*) denotes the aspects addressed in the survey. Pie chart (a) represents the distribution of student satisfaction for the overall online course, while pie charts (b-f) illustrate satisfaction distributions for specific learning materials, including syllabus, digital textbook and courseware (b), quizzes (c), discussion sections (d), homework (e), and question & answer section (f) of the online course, respectively.

3.3. Effect of the Online Course on SDL Capacities

Surveys administered before and after the online course yielded scores for each item in the rating scale. The total and 4-dimension scores are shown in Table 4. We computed both the total scores and scores of each dimension for each student. Notably, no students were rated as having low levels of SDL capacities. The majority of students (n = 65, 81.25%) were rated at a middle level at the beginning of the learning; however, this proportion dramatically decreased to 69.85% (n = 51)

by the end of the course. Consequently, the number of students categorized as having high levels of SDL increased from 15 (18.75%) to 22 (30.4%) over the learning process. While this change is meaningful, the Chi-square test did not yield statistically significant differences (Figure 2a). Nevertheless, the average total rating score increased from 58.6 to 61.9 throughout the course. The unpaired student's t-test demonstrated a significant difference between the two-time points (Table 4, Figure 2b). Apart from this, significant increases were also observed in the aspects of learning motivation, self-management, and learning cooperation and coordination (Figures 2c-e). In contrast, no significant difference was noted in the ability of information processing (Figure 2f). Furthermore, we observed significant changes in the learning habits of participants. After two months of online learning, students tended to favor completing their lessons using randomly fragmented time (n = 44, 59.46%) over specifically planned time (n = 30, 40.54%). A Chi-square test confirmed the statistical significance of this trend, suggesting that the online course played an important role in shaping participants' learning habits (Figure 3a). Final test scores between offline learning (2022) and online learning (2023-2024) cohorts were compared with unpaired student's t-test. No significant difference was observed in the analysis, suggesting that the promotion of SDL or the changes in learning habits might not have a discernible effect on test scores, particularly after a relatively short learning period of two months (Figure 3b).

Table 4. The total and dimensional scores of SDL capacities.

Category	Scores	
	Pre-course (n = 80, Mean ± SD)	Post-course (n = 74, Mean ± SD)
Total (18 items)	58.60 ± 8.36	61.92 ± 8.77
Learning motivation (5 items)	18.39 ± 2.88	19.58 ± 3.04
Self-management (7 items)	20.76 ± 4.30	22.45 ± 4.60
Collaboration (2 items)	5.43 ± 2.04	6.41 ± 2.16
Information processing (4 items)	14.03 ± 2.56	13.49 ± 2.69

4. Discussion

SDL has been on a fast track in the development of adult education over the past few decades (Williamson, 2007: pp. 66-83). As the health professions continuously advance, educators are increasingly focusing on the concept of SDL in medical education (Sahoo, 2016: pp. 166-169). The emergence of online learning platforms has led to remarkable shifts in learning behaviors, resulting in marked improvement in areas such as learning motivation, self-management, collaboration, and information processing (Xu et al., 2022). The primary objective of this study was to assess the impact of an online course on the promotion of SDL among third-year medical students. The findings suggest that our two-month online course was well-designed and well-suited for the students, demonstrating a substantial increase in students' SDL capacities and an evident influence of online learning on shaping their learning behaviors.

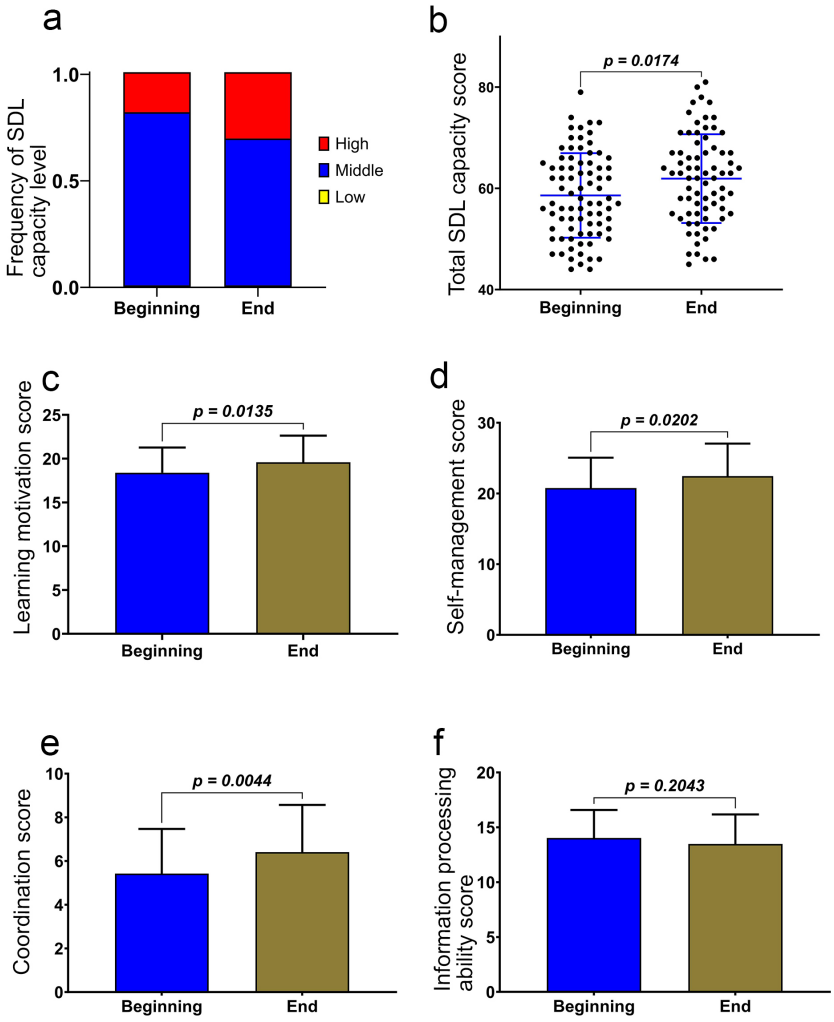

Figure 2. Comparisons of students' SDL capacities over online learning. Panel (a) depicts the frequencies across three SDL levels. Panels (b-f) compare the total and dimensional SDL capacity scores at the beginning and end of the online course. Statistical analyses were conducted simultaneously.

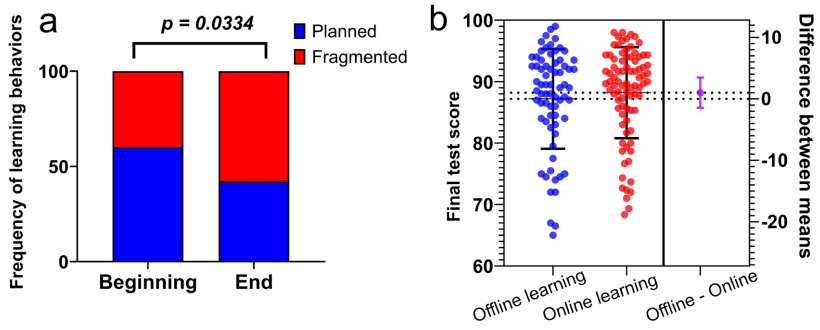

Figure 3. Comparisons of students' learning habits over the online learning experience and test scores between offline and online learning. The frequencies of two distinct learning habits (planned time learning vs. fragmented time learning) at the beginning and end of the online course are presented in panel (a). The test scores for the students who completed the course offline in 2022 and those who experienced online learning in 2023-2024 are displayed as blue and red dots, respectively, in panel (b).

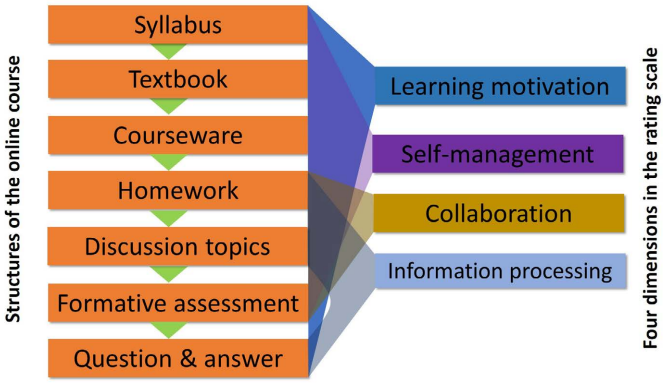

Figure 4. Schematic representation of the online course structure and the interrelationships between the course components and the rating scale.

Several factors likely facilitated the enhancement of SDL. Foremost among these is student preparedness (Fisher, King, & Tague, 2001: pp. 516-525; Williams, 2004: pp. 277-285). Students must possess self-management skills to engage in a long period of self-learning; otherwise, they risk failing to gain any improvement in their SDL capacities and might face bad learning outcomes (Williams, 2004: pp. 277-285). In our case, the third-year medical students had completed two semesters of medical courses, indicating their adaptation to the professional context and collaboration with peers. This background rendered them well-suited for adult learning principles. Moreover, students were already familiar with internet technologies and personal digital devices (e.g., laptops, tablets, smartphones, and desktops), enabling them to troubleshoot common online learning issues. More than half of the students in this study preferred accessing online courses for their learning activities. All participants were rated at or above the middle level of SDL capacity, demonstrating their well-preparedness at the outset of the course. Therefore, none reported experiencing anxiety or fear regarding online learning, which contrasts with findings from other studies (Hewitt-Taylor, 2001: pp. 496-504; Hewitt-Taylor, 2002: pp. 33-38; Lunyk-Child et al., 2001: pp. 116-123; Miflin, Campbell, & Price, 2000: pp. 299-306). It is evident that adequate preparation plays a crucial role in ensuring high learning motivation prior to embarking on a new course.

An intriguing finding of this study was the transformation in students' learning habits over the online learning experience. Statistical analysis confirmed an increase in the number of students who preferred using fragmented time for online learning, a trend previously noted in early reports (Jue Zhu & Jia, 2019: pp. 87-89+92; Yang & Wu, 2021: pp. 66-69). The user- and device-friendly nature of our online platform may have contributed significantly to this trend, as students could conveniently access the online course via tablets, laptops, desktops, and even smartphones, thus reshaping their learning behaviors over the two months. While fragmented learning can pose challenges to knowledge integration, our study did not reveal evidence

of diminished performance in test scores following the online learning. The impact of online learning on these behaviors warrants further investigation (Jue Zhu & Jia, 2019: pp. 87-89+92).

The design of online courses also plays a pivotal role in promoting SDL. It is essential to strategically construct online learning environments that effectively cultivate learning motivation and facilitate engagement with each component of the course. A systematic review and meta-analysis discovered no significant difference in test scores between online learning and offline learning (Pei & Wu, 2019). However, an effective online learning environment can offer superior flexibility compared to traditional offline settings, thereby aiding students in practicing and developing their SDL capacities (Jin et al., 2022: pp. 130-147). In this study, task-oriented lessons were established in the course framework. Each lesson is comprised of seven sections designed to promote different dimensions of SDL (**Figure 4**). Given that our students already exhibited relatively high motivation, it was critical to implement a well-structured course and instructional strategies to enhance teaching presence, learning presence, and cognitive presence, ultimately encouraging students to complete online learning tasks. While aspects of learning motivation were effectively improved, we observed limitations in students' abilities related to information seeking, indicating potential shortcomings in the corresponding sections: discussion, homework, and question & answer. The limitations may stem from insufficient teaching presence or a misalignment between learning content and information processing. Additionally, the possibility that open-ended questions in the discussion section failed to attract students' attention, thereby contributing to reduced engagement in information processing activities, warrants consideration. Some unique components, such as interactive online workshop, could potentially encourage students' engagement and strengthen their ability to process information (Phillips, Johnson, Khalid, Zapparrata, & Albright, 2023: pp. 270-275). Nevertheless, the task-oriented lessons in our course proved effective in promoting other SDL dimensions, leading to an overall improvement of SDL capacities. High levels of student satisfaction further demonstrated that the course was well-structured. These results align with previous studies that emphasize the importance of helping students establish learning goals, retrieve learning content, and identify learning resources (George, Reis, Dobson, & Nothnagle, 2013: pp. 289-293; Rosemary Kim et al., 2013: pp. 150-160; Si, 2022: pp. 145-154; van Houten-Schat et al., 2018: pp. 1008-1015). Therefore, educators are encouraged to focus on optimizing online courses at every level. SDL capacities can be reasonably improved when educators prioritize the optimization of learning goals, content, structure, processes, and self-assessment within a course, making student capacity assessments reliable indicators of successful outcomes. In 1977, Guglielmino developed a practical SDL readiness scale (SDLRS), which has been broadly applied to evaluate nursing students (Fisher, King, & Tague, 2001: pp. 516-525; Fisher & King, 2010: pp. 44-48; Guglielmino, 1977). However, the instrument is not ideally suited to assess students' SDL behaviors, which differ

from their readiness for SDL (Ralph & Brockett, 1991). Several independent self-report tools have been developed globally (Cheng, Kuo, Lin, & Lee-Hsieh, 2010: pp. 1152-1158; Fujino-Oyama, Maeda, Maru, & Inoue, 2016: pp. 65-71; Williamson, 2007: pp. 66-83), but most are tailored to specific populations, such as healthcare professionals, to ensure validity. Considering the diverse conditions and characteristics of medical education across various cultures and countries, we modified a well-validated rating scale developed by Wang and colleagues in China for this study. The scale was initially created for assessing medical students in an online environment and demonstrated validity and reliability (Ling et al., 2021: pp. 1080-1084; Suzhen, 2014: pp. 1034-1037). In this study, the scale was proved to effectively reflect the students' SDL competence. However, the development of self-report tools is a dynamic process, and further verification and refinement of the scale is necessary in the future.

The present study does have certain limitations. The long-term effects of the online course on SDL were not assessed, limiting the reliability of the findings regarding our two-month online course. The findings did not reflect the gradual behavioral changes of our students. Additionally, the participant pool was restricted to undergraduate medical students, which may constrain the generalizability of our conclusions to students from diverse academic backgrounds or educational stages. To enhance the sustainability of SDL, future research should investigate SDL strategies over extended periods and among students across a broader spectrum of fields.

5. Conclusion

Our online course has positively influenced the enhancement of students' SDL, particularly in the dimensions of learning motivation, self-management, and collaboration. While the overall impact of the online course is evident, further improvement is needed to strengthen the information processing capacities of the students. To achieve this, the course should focus on the incorporation of interactive activities in each lesson that propel students to dive deep into analysis, synthesize complex information, and apply their newfound knowledge in real-world scenarios.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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