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An investigation of self-directed learning among Chinese undergraduates from the perspective of metacognition

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ABSTRACT

Self-directed learning (SDL) constitutes an essential means for undergraduates to adapt to rapid societal changes, and metacognition, which serves as the regulatory centre, plays a crucial role in enhancing learning effectiveness. Drawing on a metacognitive perspective, this study adopted a mixed-methods approach to examine the current state, problems, and underlying causes of Chinese undergraduates' SDL. The results indicated that undergraduates' SDL competence was generally above the intermediate level, with the most robust performance observed in the goal-setting dimension, and students from different academic years and with different performance levels exhibited varying outcomes across all SDL dimensions. The following issues were also identified: insufficient dynamic adjustment and goal precision, limited flexibility in strategy selection and weak competence in employing tools, inadequate real-time process monitoring coupled with a lack of emotional regulation, insufficient depth in evaluation and reflection, difficulties in transfer and application, and polarised resource utilisation. The underlying causes of these issues included a lack of metacognitive knowledge, restricted technological literacy, and the absence of monitoring mechanisms. These findings provide empirical evidence to support the cultivation of SDL competence among undergraduates in Chinese higher education.

Keywords: self-directed learning, Chinese undergraduates, metacognition

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INTRODUCTION

In an era characterised by rapid knowledge renewal and the inevitable rise of lifelong learning, the ability to proactively adapt and steer one's own learning progress has become important. Self-directed learning (SDL), as a pivotal learning paradigm, has attracted growing attention within the field of education. This concept was first expounded by Knowles (1975). Knowles (1975) defined SDL as a process in which learners, with or without external assistance, actively diagnose their learning needs, establish learning goals, identify learning resources, select and implement suitable learning strategies, and evaluate learning outcomes. Rooted in humanist, pragmatist, and constructivist thought, SDL emphasises learner autonomy, initiative, and responsibility (Tough, 1989; Zhao, 2019). It is not merely a choice of learning method; rather, it involves learners independently assuming responsibility for the complete learning process–from conceptualisation to assessment–while engaging in learning and problem-solving across diverse contexts extending beyond conventional classroom settings (Brookfield, 2009; Houle, 1961; Khalid et al., 2020). In sum, the core components of SDL include learner autonomy, comprehensive management of the learning process, heterogeneity in learning environments, and the requisite capacity for learning regulation.

The concept of metacognition was first introduced by American developmental psychologist Flavell (1979). He defined metacognition as an individual's knowledge concerning their own cognitive processes, outcomes, or other related matters, which can also be regarded as the active and continuous monitoring of one's cognitive processes while pursuing a specific goal or undertaking a task. Mainstream metacognitive theory, accepted by most scholars, consists of three key dimensions: metacognitive knowledge, metacognitive experience, and metacognitive monitoring. Metacognitive knowledge relates primarily to individuals' understanding of the processes and outcomes of their own or others' cognitive activities. Metacognitive experience refers to the cognitive and affective experiences generated throughout cognitive activities. Metacognitive monitoring involves the conscious oversight of one's cognitive activities during cognition (Dunlosky & Metcalfe, 2008).

For undergraduates, cultivating SDL skills is both urgent and crucial. The university environment places great emphasis on independent exploration and critical thinking, requiring students to assume primary responsibility for managing their studies. Nevertheless, undergraduates are at a key juncture in the development of their

cognitive and metacognitive abilities–capacities that, whilst malleable, are not yet fully formed. Many undergraduates face notable difficulties with SDL, including vague learning objectives, insufficient motivation (Li, 2023), low classroom engagement, inadequate preview and review habits (Fang et al., 2024), and limited self-monitoring and reflective evaluation abilities (Tian, 2023). These issues not only diminish their current academic efficiency and depth of learning but also undermine their ability to adapt to the swift social and professional changes that lie ahead.

Whilst the significance of SDL is now acknowledged, and related research has continued to grow, certain gaps persist in extant studies on undergraduates' SDL in Chinese higher education. Existing studies have often targeted students from specific disciplines or academic years, constraining the generalisability of their findings (Bu et al., 2022). Furthermore, most studies have not comprehensively scrutinised the diverse dimensions influencing SDL, particularly failing to highlight or separately examine the metacognitive factors that serve as the principal regulating mechanism within cognitive processes (Zhang et al., 2024). Metacognition underpins key stages in SDL, including self-diagnosis, goal setting, strategy selection, process monitoring, and result evaluation, yet its precise role and current status among undergraduates remain largely under-investigated (Liu et al., 2022).

Accordingly, this study adopted a metacognitive perspective to examine in depth the SDL of undergraduates in Chinese universities. The study focused on metacognitive planning, monitoring, evaluation, and regulation manifested during the SDL process of undergraduates and identified specific issues and their root causes. The findings obtained can serve as empirical evidence for proposing targeted strategies to enhance SDL, optimising higher education teaching practices, and ultimately helping undergraduates develop into proficient lifelong learners. Therefore, two core research questions arise:

1. How do Chinese undergraduates demonstrate metacognitive abilities in the SDL process?
2. From a metacognitive perspective, what key challenges do Chinese undergraduates encounter in SDL and what are the underlying causes?

METACOGNITIVE VIEW OF SDL CHARACTERISTICS AMONG UNDERGRADUATES

From a metacognitive perspective, SDL among undergraduates is fundamentally a process whereby learners actively regulate their learning activities through metacognitive abilities. Considering the distinctive attributes of undergraduate students, its core characteristics may be summarised in the following five aspects.

Goal Setting: Aligning Personal Learning Plans with Adaptive Adjustments

Goal setting refers to the process by which an individual or organisation determines specific objectives or standards to achieve particular outcomes or fulfil certain aims. It typically involves clarifying one's own capabilities, outlining key tasks, and formulating and adjusting attainable goals. Drawing on metacognitive knowledge, undergraduates can gain deeper insights into their own learning styles, knowledge reserves, and needs, thereby setting goals that strike a balance between being suitably challenging and realistically aligned with their actual circumstances. Goal setting anchored in self-awareness thus proves both reasonable and attainable while simultaneously stimulating students' motivation. During learning, students rely on metacognitive monitoring to gauge any discrepancies between their current progress and stated goals in real time; through metacognitive regulation, they can flexibly adjust these goals, ensuring that their aspirations consistently match their prevailing learning state.

Strategy Selection: Flexibly Choosing and Refining Learning Methods Based on the Context

Strategy selection denotes an individual's conscious endeavour, when confronting different learning tasks or problem contexts, to choose and switch methods, tools, or strategies best suited to their personal characteristics, task demands, and environmental conditions, all aimed at high efficiency learning and problem-solving. This approach underscores the individual's capacity to flexibly apply and adjust learning strategies depending on the context, forming a vital component of SDL. Metacognitive regulation enables undergraduates to choose and refine learning strategies flexibly, informed by the nature of each task and the real-time situations unfolding during the learning process, thus enhancing the utility and diversity of these strategies. By leveraging metacognitive regulation to guide strategy selection, learners discover the most fitting strategy combinations for their current learning contexts, thereby improving both efficiency and quality of learning.

Process Monitoring: Continuous Observation and Dynamic Regulation of Learning Progress

Process monitoring refers to an individual's ongoing surveillance and regulation of factors, including their behaviour, progress, resource usage, and emotional state, such that the activity proceeds in line with predetermined goals and plans. It also ensures that any deviations are promptly identified and addressed, thereby boosting both the quality and efficiency of task completion. This concept emphasises self-awareness and self-regulatory capability, representing a critical element of SDL and independent management. Metacognitive monitoring permeates every stage of undergraduates' learning, constantly tracking their learning progress, comprehension, and level of attention. When internal metacognitive monitoring detects signs of distraction, it activates regulatory mechanisms, while external metacognitive monitoring can involve the utilisation of additional tools to conduct quantitative assessments of the learner's study status. Once a learner, guided by metacognitive monitoring, recognises a cognitive deviation, they proactively correct their course and adjust their learning strategies in a timely manner, thereby improving learning efficacy and outcomes.

Evaluation and Reflection: Systematic Assessment of Learning Effectiveness and Planning for Future Progress

Evaluation and reflection involve systematically assessing, analysing, and summarising the learning process and its results to determine the extent to which goals have been achieved, identify strengths and weaknesses within the learning experience, and devise strategies for improvement and future study plans. It highlights critical thinking and self-awareness, serving as a crucial stage for both SDL and sustained improvement. Metacognitive evaluation abilities enable undergraduates to impartially and comprehensively judge their own learning achievements and to reflect on the entire learning process. Learners acquire awareness of how effectively they have mastered

certain knowledge and can critically appraise the efficacy of their methods, time management, and the appropriateness of their selected strategies. Reflections and lessons derived from metacognitive evaluation then inform subsequent learning, guiding students to make continual progress.

Support Systems: Multidimensional Resources and Environments That Foster Undergraduates' Metacognitive Skills

Support systems specifically refer to the external resources or environments on which individuals can rely, including interpersonal aid and technological support. Teachers constitute the most direct support system for developing students' metacognitive abilities, as they guide students in selecting appropriate learning methods, enhance their metacognitive knowledge, and deepen their command of disciplinary content, thus offering professional support in building undergraduates' metacognitive competences. Collaborative learning and discussions with peers afford diverse perspectives on learning approaches and methodologies, inspiring fresh ways of thinking and fostering improved comprehension and application of knowledge. Meanwhile, a wide range of learning resources provides a robust foundation for undergraduates' SDL, accommodating learners' diverse needs and preferences.

RESEARCH METHODOLOGY

This research adopted a mixed-methods approach, more specifically, the explanatory sequential design (Creswell & Creswell, 2017).

Quantitative Phase

Research participants

In this study, full-time undergraduates from regular higher education institutions were selected as survey participants, with samples drawn from first- to fourth-year students across various majors. A convenience sampling method was employed, with data collected via the Wen Juan Xing platform. A questionnaire link was distributed primarily via social media platforms such as WeChat and QQ. Of the 477 questionnaires received, 433 were valid, after excluding those submitted in an abnormally short time and those featuring identical answers. This yielded an effective response rate of 90.78%. The demographic characteristics of the participants are presented in **Table 1**.

Table 1. Demographic characteristics of the participants

Variable	Option	Frequency	Percentage (%)
Gender	Male	210	48.6
	Female	223	51.4
Academic year	Year 1	73	16.8
	Year 2	111	25.6
	Year 3	108	24.9
	Year 4	141	32.7
Major	Philosophy	11	2.5
	Economics	32	7.4
	Management	125	29.0
	Sciences	82	18.9
	Law	14	3.2
	Education	59	13.6
	Engineering	26	6.0
	Arts	15	3.5
	Literature	37	8.5
	History	5	1.2
	Agriculture	5	1.2
	Medicine	22	5.1
Average academic performance	Above 90	49	11.5
	80-89	290	66.8
	70-79	80	18.4
	Below 70	9	2.1
	Uncertain/prefer not to answer	5	1.2

Survey instrument

A structured questionnaire served as the research instrument. Following a small-scale pilot study (N = 156), items failing to meet the reliability and validity criteria were removed, leading to the final version of the questionnaire. The questionnaire comprised two sections: the first collected the participants' demographic information, including their sex, academic year, major, and recent academic performance; the second assessed SDL ability across five dimensions–goal setting, strategy selection, process monitoring, evaluation and reflection, and support system–using a five-point Likert scale (ranging from 'strongly disagree' to 'strongly agree'). To ensure reliability and validity, the items for each dimension were based on prior studies (Dong, 2009; Tian, 2005; Zhang et al., 2025; Zhao, 2021; Zimmerman, 2000).

Reliability and validity testing

SPSS was used to test the reliability and validity of the sample data. The Kaiser-Meyer-Olkin value stood at 0.922 (> 0.7), and Bartlett's test of sphericity returned an approximate chi-square of 2,235.800 at a significance level of $p = 0.000$ (< 0.01), indicating a very high degree of structural validity. Cronbach's alpha was 0.878, implying good reliability (as Cronbach's alpha values above 0.7 are considered good, and those between 0.6 and 0.7 are considered acceptable).

Qualitative Phase

To further elucidate and enrich the quantitative findings and gain deeper insight into the underlying reasons, mechanisms, or specific manifestations revealed by the quantitative data, follow-up interviews were conducted. A semi-structured interview protocol was prepared, focusing on the core research questions through a metacognitive lens and addressing topics such as goal setting, learning methods, planning and evaluation, and support seeking. Interviewees were selected from among the original survey respondents using stratified sampling, dividing them into low-achieving, high-achieving, and intermediate groups, with three participants in each category. **Table 2** presents basic information about the interviewees. We analysed the interview data based on Braun and Clarke's (2006) thematic analysis approach. We followed the key steps of familiarisation, coding, and theme development to identify significant patterns and insights related to the characteristics of undergraduates' SDL.

FINDINGS AND DISCUSSION

Quantitative Phase

This section aims to address research question 1: How do Chinese undergraduates demonstrate metacognitive abilities in the SDL process?

Table 2. Demographic characteristics of the interviewees

		Sex	Major	Academic Year	Academic performance (last year)
Low-achieving group	A	Male	Economics	Year 3	Below 70
	B	Female	Sciences	Year 3	70-79
	C	Female	Sciences	Year 2	70-79
High-achieving group	D	Male	Management	Year 2	80-89
	E	Female	Education	Year 4	80-89
	F	Male	Literature	Year 4	Above 90
Intermediate group	G	Male	Law	Year 1	80-89
	H	Female	Arts	Year 3	Above 90
	I	Male	Management	Year 1	80-89

Table 3. Performance of the undergraduates across various dimensions of SDL

Item	Mean	SD	Skewness	Kurtosis
Goal setting	**3.90**			
A1. I can clearly describe my own learning style (e.g., visual or auditory learner).	3.78	0.753	-1.04	1.848
A2. I am aware of which learning domains I am strong in and those I am weak in (e.g., memory, logical reasoning).	4.05	0.831	-0.846	0.705
A3. I can accurately judge the level of difficulty of different learning tasks (e.g., essay writing vs. multiple-choice exercises).	3.88	0.817	-0.732	0.837
A4. When the learning environment changes, I proactively adjust my original learning goals.	3.86	0.788	-0.714	0.579
A5. I can dynamically adjust my learning pace according to my schedule.	3.91	0.873	-0.767	0.311
Strategy selection	**3.77**			
B1. When tackling different subjects, I adopt various learning methods.	3.82	0.879	-0.647	0.146
B2. I can select learning strategies according to the type of task (e.g., mind maps or retrieval practice).	3.85	0.869	-0.722	0.238
B3. When I realise a strategy is inefficient, I can swiftly switch to a new one.	3.55	0.92	-0.257	-0.62
B4. I can regulate my learning input intensity based on task difficulty.	3.87	0.825	-0.754	0.688
Process monitoring	**3.66**			
C1. I continuously check whether I have strayed from my intended direction throughout the learning process.	3.59	0.921	-0.618	-0.064
C2. I use periodic reviews to ensure I complete tasks on time.	3.73	0.949	-0.546	-0.227
C3. When my existing resources are lacking or inadequate, I proactively seek alternatives.	3.94	0.846	-0.894	0.961
C4. Online learning platforms (e.g., MOOCs) significantly expand my repertoire of learning strategies.	3.54	1.065	-0.568	-0.45
C5. When my emotions fluctuate, I have clear methods for maintaining my study state.	3.56	0.994	-0.625	-0.205
C6. I quickly detect distractions in my own attention and make quick adjustments.	3.63	0.983	-0.443	-0.476
Evaluation and reflection	**3.68**			
D1. After completing a learning task, I systematically assess the extent to which my goals have been achieved.	3.64	0.99	-0.65	-0.145
D2. I often analyse the deeper reasons for my learning outcomes (e.g., concept confusion vs. time management).	3.57	0.984	-0.587	-0.324
D3. I can distinguish between superficial learning and true mastery.	3.76	0.9	-0.569	-0.012
D4. The outcomes of my reflections directly inform improvements in my subsequent learning.	3.77	0.9	-0.63	0.246
Support systems	**3.64**			
E1. I make good use of teachers/seniors to refine my study strategies.	3.65	1.015	-0.77	0.124
E2. Group discussions help me discover gaps in my own knowledge.	3.63	0.956	-0.887	0.447

Overview of the undergraduates' SDL

This study examined the status of undergraduates' SDL across five dimensions–goal setting, strategy selection, process monitoring, evaluation and reflection, and support systems (see **Table 3**). Among these five dimensions, the highest total mean score was observed for goal setting (3.90), indicating that the undergraduates generally perceived themselves as performing well in formulating learning goals. Within this dimension, A2 (awareness of one's own learning domain) had the highest score (4.05), whilst A1 (describing one's learning style) recorded the lowest mean (3.78), suggesting that although most students could identify their learning style, some were still uncertain. This was followed by the strategy selection dimension, with a mean of 3.77. B4 (regulation intensity) showed the highest mean (3.87) and the most pronounced skewness (0.754), signifying a marked tendency for higher ratings in the students' perceptions of their capacity to adjust learning input intensity. B3 (strategy switching) emerged with the lowest mean (3.55) and the largest standard deviation (SD) (0.92), while its kurtosis was -0.62. Together, these results indicated a lower self-evaluation and a relatively dispersed and flat distribution, suggesting this may be a weaker area for many students. Next was the evaluation and reflection dimension (mean = 3.68), revealing that the students generally rated themselves slightly above average in this area. D4 (using reflective outcomes to improve subsequent learning) had the highest mean (3.77), suggesting that most students believed that their reflections effectively informed future study. D2 (analysing underlying causes of success and failure) had the lowest mean (3.57), reflecting a potential lack of depth in attribution analysis, which required targeted enhancement. The process monitoring dimension scored a mean of 3.66, indicating that the undergraduates considered themselves slightly above average in this area. C3 (actively seeking alternative resources) had the highest mean (3.94), implying that the students generally possessed an ability to adjust their resources when necessary. C4 (online learning platforms expanding one's strategy repertoire) yielded the lowest mean (3.54), indicating insufficient utilisation of online learning platforms. It also showed the largest SD (1.065), suggesting significant variability in the students' evaluations of online platforms, which may reflect differences in usage experience or academic subject areas. Finally, the dimension of support systems had a mean of 3.64, showing that, overall, the undergraduates rated themselves well in this area. They notably excelled at identifying their own cognitive blind spots

Table 4. Tests of differences in SDL across distinct sample characteristics (Mean ± SD)

Characteristic	Goal setting	Strategy selection	Process monitoring	Evaluation and reflection	Support systems
Male	3.922 ± 0.548	3.791 ± 0.621	3.687 ± 0.600	3.737 ± 0.684	3.657 ± 0.746
Female	3.871 ± 0.517	3.755 ± 0.621	3.642 ± 0.609	3.635 ± 0.641	3.623 ± 0.791
T/F	0.998	0.603	0.779	1.607	0.457
Year 1	3.767 ± 0.480	3.333 ± 0.585	3.417 ± 0.274	3.375 ± 0.586	3.833 ± 0.516
Year 2	3.415 ± 0.839	3.500 ± 0.866	3.321 ± 0.783	3.289 ± 0.770	3.385 ± 0.682
Year 3	3.737 ± 0.892	3.553 ± 1.016	3.623 ± 0.904	3.618 ± 0.922	3.500 ± 1.080
Year 4	4.036 ± 0.435	3.889 ± 0.415	3.630 ± 0.528	3.756 ± 0.540	3.611 ± 0.563
T/F	**3.502***	2.383	0.880	1.865	0.649
Natural sciences	3.839 ± 0.544	3.743 ± 0.631	3.647 ± 0.621	3.606 ± 0.669	3.563 ± 0.811
Humanities	3.962 ± 0.554	3.835 ± 0.678	3.637 ± 0.690	3.750 ± 0.710	3.713 ± 0.803
Social sciences	3.910 ± 0.517	3.771 ± 0.598	3.682 ± 0.569	3.711 ± 0.645	3.663 ± 0.732
T/F	1.384	0.496	0.220	1.471	1.090
Above 90	4.188 ± 0.419	4.010 ± 0.547	3.895 ± 0.659	3.980 ± 0.653	3.867 ± 0.828
80-89	3.908 ± 0.494	3.810 ± 0.561	3.679 ± 0.561	3.697 ± 0.639	3.693 ± 0.729
70-79	3.765 ± 0.559	3.584 ± 0.713	3.533 ± 0.622	3.553 ± 0.622	3.413 ± 0.791
Below 70	3.156 ± 0.893	2.944 ± 0.873	3.148 ± 0.963	2.972 ± 1.071	2.778 ± 0.755
Uncertain/prefer not to answer	3.720 ± 0.610	3.700 ± 0.837	3.533 ± 0.582	3.400 ± 0.602	3.500 ± 0.354
T/F	**10.232****	**8.474****	**4.612****	**6.356****	**6.340****

Note. **p and *p represerepresentsicance levels of 0.01 and 0.05, respectively

through group discussions (E2, mean = 3.63, SD = 0.956). Although the students generally performed well in taking advantage of teachers or senior classmates to optimise learning approaches (E1, mean = 3.65), there remained substantial individual variation (SD = 1.015), indicating a need for further guidance and support.

Differences in the undergraduates' SDL

To investigate the differences in the undergraduates' SDL, this study examined four sample characteristics–sex, academic year, major, and academic performance–and compared their effects on SDL. Specifically, taking these characteristics as independent variables, independent-samples t-tests and analyses of variance were conducted for each SDL dimension. The results are presented in **Table 4**.

Regarding sex, no statistically significant differences ($p > 0.05$) emerged in the mean scores across any of the SDL dimensions, indicating that the undergraduates did not differ substantially in terms of sex in their performance on these dimensions. Concerning academic year, a notable distinction was identified in the goal-setting dimension ($p < 0.05$). Specifically, the fourth-year students obtained the highest mean (4.036) and the smallest SD (0.435), suggesting that their goal setting was not only the most stable but also the strongest, whereas the first-year students attained the lowest mean (3.767). This could be because, as students progress in their studies, their awareness of personal learning objectives becomes clearer, and they become more adept at formulating goals. Conversely, no significant year-group differences were found for strategy selection, process monitoring, evaluation and reflection, or support systems. Concerning major, the 12 professional fields were regrouped into three categories–humanities, social sciences, and natural sciences. The group analysis yielded no significant between-group differences ($p > 0.05$) in any dimension, implying that the students of different academic specialisations did not exhibit marked variations in their SDL. In terms of academic performance, the results revealed significant mean-score differences across all SDL dimensions among different performance groups ($p < 0.01$), indicating a considerable correlation between the students' academic performance and their SDL. Higher-scoring students (above 90) reported the highest means with relatively small SD, indicating consistent performance. Those who scored below 70 had the lowest means and larger SD, reflecting considerable individual variability, which can be attributable to multiple influencing factors.

Qualitative Phase

This section aims to address research question 2: From a metacognitive perspective, what key challenges do Chinese undergraduates encounter in SDL and what are the underlying causes?

The findings indicated that the undergraduates showed inadequate dynamism and precision in goal setting, particularly in understanding their learning styles (A1 scoring low) and adjusting goals in real time (A4 scoring low). These capabilities were notably weaker among underperforming students than among their higher-achieving peers. Garrison (1997) posited that learners engaged in SDL must be able to dynamically formulate and adapt their goals, making flexible modifications to both their goals and strategies based on internal and external feedback. We noted that some students overlooked the importance of recognising their own learning styles. For instance, participant C from the low-achieving group believed that assessing personal abilities has no relevance to carrying out teacher-assigned tasks: 'I never evaluate myself before study because the teacher sets our learning objectives. Regardless of my strengths or weaknesses, I must pass the course, so evaluating myself has nothing to do with whether I need to acquire this knowledge. Mastering the content is simply something I must do'. Moreover, the students did not always accurately gauge the difficulty of tasks relative to their own capabilities, resulting in unrealistic goal setting. For example, participant B, another low-achieving student, allocated study time by evenly dividing the total amount of material, remarking, 'When studying molecular biology (taught via self-study with in-class exercises), I try to review the PowerPoint slides before each session, starting two weeks in advance. I divide the slides evenly across days and then do my best to complete the exercises in class'. In addition, learning objectives were often overly rigid, with the students showing limited awareness or strategies for adapting them in response to changing circumstances (e.g., disruptions to one's schedule or making use of fragmented time). This shortfall

appears to be linked to inadequate metacognitive monitoring, path dependence, and an overreliance on external support.

The undergraduates also exhibited limited flexibility in strategy selection and a weak ability to access and utilise tools, manifested in the difficulty of switching strategies (low mean for B3), the inability to adjust learning input effectively in line with task difficulty (large SD for B4), and insufficient exploitation of technology-based resources to diversify learning strategies. Students frequently relied on a single, rigid learning method, lacking cross-disciplinary competency in matching strategies to tasks. As participant D, a high-achieving student, recounted, the transition from sciences to the study of literature was profoundly jarring: 'I took a science track in secondary school but chose Chinese language and literature at university due to my interest in it. At first, I was completely unprepared–there were no problem sets, yet the course content was extensive and demanded heavy memorisation. I was not used to this way of studying at all. Consequently, I resorted to rote memorisation and last-minute cramming, producing poor results consistently, to the point that I even considered changing majors'. This illustrates pronounced path dependence and adaptation difficulties. Garrison (1997) underlined that metacognitive self-monitoring is essential for dynamically adjusting learning strategies. Without adequate metacognitive skills (such as evaluating the match between task difficulty and personal competencies), strategies can become inflexible. Furthermore, many students' understandings of intelligent tools remained confined to their basic functions, without deep integration to customise learning pathways, which appears linked to an instructional emphasis on content coverage over strategy development, combined with limited technological literacy.

The undergraduates exhibited a lack of real-time responsiveness in process monitoring and showed insufficient emotional regulation capacity, as particularly manifested when experiencing emotional fluctuations and attention lapses (with low scores for C5 and C6). The low-achieving students, in particular, scored notably lower in these monitoring abilities than their high-achieving counterparts, making them more susceptible to cognitive disruption. This shortcoming derives from an incomplete metacognitive monitoring mechanism, preventing the formation of a real-time feedback loop and resulting in 'metacognitive monitoring failures' under pressure, whereby students may overestimate their abilities or underestimate the difficulty of tasks. Some learners adopted passive emotional regulation and haphazard attention management, relying on subjective feelings rather than a systematic method of monitoring. For instance, participant A from the low-achieving group indicated, 'I mainly rely on learning outcomes like my accuracy in answering questions. During the learning process, I just gauge whether I have mastered the material based on what I feel or look at how much stationery I have used'. Such remarks reveal ambiguous monitoring standards and a neglect of process details. Inadequate closed-loop monitoring can lead to partial information awareness, mismatched adjustment measures, and a lack of meaningful feedback, further exacerbating monitoring failures and disruptions under conditions of high stress. Brookfield (2009) argued that the essence of SDL is learners' control over their learning process. Problems such as insufficient monitoring, a lack of emotional regulation, and cognitive disruptions underscore deficiencies in learners' capacity for such control.

The study also showed that the undergraduates encountered restricted depth in evaluation and reflection, along with limited transfer capacity, typified by superficial attributions and weak learning transfer, ultimately making it difficult for reflections to become a robust impetus for cognitive enhancement. This finding reveals the practical challenges in the key assessment stage of SDL, as discussed by Brookfield (2009). Brookfield (2009) cautioned against perspectives that neglect the quality of SDL and the requisite self-awareness of learners. The 'shallow attributions' and homogenised remedial strategies observed in this study indeed reflect inadequate evaluation quality and restricted self-understanding. It appears that students may not achieve the 'authentic, critical control' that Brookfield (2009) highlighted, which goes beyond superficial reflection to account for culturally formed influences. Instead, their reflection seems more akin to a conditioned response than an in-depth self-examination, thus limiting its capacity to guide subsequent learning and resulting in a disconnect between reflection and practice that stifles the full realisation of SDL.

Brookfield (2009) further stressed that the individual does not accomplish SDL in isolation and that resource utilisation (including peer support) is vital. However, the present study revealed significant group differences in the undergraduates' adoption of learning support systems, with certain students demonstrating strong dependence on their teachers and seniors and others disregarding such resources entirely. The low-achieving students, who were in particular need of assistance, often obtained minimal support due to insufficient help-seeking abilities or limited access channels. As teaching practices predominantly focused on knowledge transmission in lieu of metacognitive strategy training, and with online resources not meeting personal demands, the overall support system displayed structural deficiencies and malfunctions. The interviews revealed that the high-achieving students made proactive use of diverse resources, including their teachers, peers, and the Internet, while the intermediate and low-achieving groups rarely considered asking teachers for help. Participant H from the intermediate group noted, 'When I realise I cannot solve the problem myself and time is genuinely tight, I will then consider external support, usually through various artificial intelligence models, to see if there might be a solution'. The existing support system has failed to effectively reach the students who need it most, creating polarisation and a vicious cycle in resource utilisation. This polarisation heightens the likelihood that educational resources will continue to gravitate towards high-performing students, contravening the principles of educational equity, while simultaneously fostering over-reliance on artificial intelligence tools and reducing human interaction for some learners.

CONCLUSION

This study employed a mixed-methods approach to investigate the current state of Chinese undergraduate students' SDL and the challenges they face, from a metacognitive perspective. By enriching and extending the application of SDL in the context of Chinese higher education, the findings provide an empirical foundation for designing more targeted support to foster undergraduates' SDL capacities and metacognitive abilities. We recommend that higher education practitioners and policymakers develop more effective interventions and optimise instructional strategies to enhance students' metacognitive skills, thereby strengthening their SDL competencies and promoting lifelong learning literacy.

An obvious limitation of this study lies in its reliance on convenience sampling and the distribution of questionnaires via social media platforms, both of which may have introduced sample selection bias and limited the representativeness of the sample and the generalisability of the findings. Moreover, the range and diversity of the interviewees were not sufficiently broad to fully capture the overall situation of the student population.

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