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The Role of Self-Directed Learning in Promoting Deep Learning Processes: A Systematic Literature Review

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Abstract

In the realm of current educational research, deep learning is extensively acknowledged as a pivotalapproach to enhancing the holistic development of students' capabilities. However, the effective facilitation of deep learning, particularly within diverse educational settings, continues to pose a significant challenge. Notably, the contribution of Self-Directed Learning (SDL) within the deep learning process and its integration into educational practices have yet to be comprehensively explored. Against this backdrop, this study engages in a systematic literature review to investigate the promotive effect of SDL on deep learning, and to analyze how strategies and environments conducive to self-directed learning can bolster the deep learning process. This article, grounded in Self-Determination Theory (SDT) and metacognitive theory, delves into the synergistic impact of self-regulation, interest and motivation, reflection and evaluation, as well as the effective application of technology on deep learning. Through an integration of existing literature, this study reveals how self-directed learning significantly enhances deep learning by fostering students' active engagement, self-management, and the development of metacognitive skills. The analysis underscores the critical role of students' personal interests and intrinsic motivation, as well as reflective and evaluative activities in deepening knowledge comprehension. It also highlights how the effective utilization of technology supports self-directed learning, further

facilitating the realization of deep learning. Although the positive relationship between Self-Directed Learning (SDL) and deep learning has been confirmed, challenges remain in effectively integrating these two modes of learning across diverse educational contexts. Future research should see educators and researchers continuing to explore innovative teaching strategies and learning environments to facilitate the effective amalgamation of SDL and deep learning.

Keywords: Self-Directed Learning, Deep Learning, Metacognitive Skills, Intrinsic Motivation.

Introduction

Deep learning represents a process through which learners engage in profound cognitive and affective processing and internalization of knowledge. In the rapidly evolving modern society, students are required not only to master knowledge but, more crucially, to think critically and apply this knowledge to solve real-world problems. Deep learning plays a key role in assisting students to adapt to future challenges and in fostering their holistic development, making it an indispensable part of contemporary education. Numerous studies have shown that deep learning encouragesstudents to cultivate their critical thinking and problem-solving abilities through inquiry, analysis, and reflection. Emphasizing the ability of students to "learn how to learn," deep learning aids in establishing habits and capabilities for autonomous learning, laying the groundwork for lifelong learning (Hsieh & Maritz, 2023; Salleh et al., 2019; Sun et al., 2023; Graaf et al., 2022).

Self-Directed Learning (SDL) is a learner-centered approach that emphasizes the initiative and autonomy of learners throughout the learning process (Lai et al., 2024). In SDL, learners are not merely recipients of knowledge but also the leaders and decision-makers in their learning journey (Evenhouse et al., 2023; Sun et al., 2023). SDL encourages learners to actively seek informationand knowledge based on their interests and needs, a proactive approach that facilitates deep exploration of learning topics and critical thinking, thereby promoting deep learning (Lai et al., 2024; Salleh et al., 2019). Through the process of setting their own learning objectives, evaluating the effectiveness of learning resources, and self-monitoring their learning progress, learners develop critical thinking and problem-solving skills (Adinda & Mohib, 2020; An & Qu, 2021; Graafet al., 2022). These skills are crucial for deep learning, as they enable learners to recognize, analyze,evaluate knowledge, and apply it to solve real-world problems (George et al., 2020; Nhat & Le, 2023).

Self-Directed Learning (SDL) and deep learning both foster a profound understanding and application of knowledge by learners (Aguiar-Castillo et al., 2021; Stephen & Rockinson-Szapkiw, 2021). Through self-directed learning approaches, learners are more likely to engage in the process of deep learning since they can choose what to learn based on their interests and needs, thereby facilitating a deeper comprehension and application of knowledge (Aguiar-Castillo et al., 2021; Lai et al., 2024). However, despite ongoing updates in scholarly research on SDL and deep learning, further investigation is required on how self-directed learning approaches can enhance the depth of students' knowledge acquisition and application, and foster the process of deep learning. Currently, there is a lack of research on specific implementation strategies for integrating SDL with deep learning. While theoretically, their combination holds great potential, how to effectively integrate these two in practice, especially across diverse educational settings, remains a challenge. Despite widespread discussion of SDL and deep learning within the educational domain, current research tends

to focus on these aspects independently, with insufficient understanding of their interaction and synergistic effects. Therefore, understanding how these elements complement each other and promote the application of knowledge and skill enhancement for educators and learners is a challenging area of exploration. This calls for a greater focus on designing and conducting empirical research to reveal how self-directed learning approaches can effectively combine with thedeep learning process, thereby providing a scientific basis for fostering deep learning and the development of critical thinking. Furthermore, exploring this domain not only aids learners in bettermastering complex concepts and skills but may also pave the way for new educational models and learning methodologies, further promoting personalized learning and the realization of lifelong learning.

This study aims to analyze the interrelationship between Self-Directed Learning (SDL) and deep learning, exploring which factors within the process of SDL can enhance the occurrence of deep learning in students, and how students experience and achieve deep learning within the context of SDL. By addressing the gaps in existing research, this study seeks to provide valuable insights tothe field of education, in support of student success in the 21st century.

Literature Review

Self-Directed Learning

The concept of Self-Directed Learning (SDL) originated from research into adult learning in the 1960s, and subsequently, the scope of SDL research has expanded to encompass all ages and educational levels. The initial focus was on recognizing adults' conscious self-direction in learning and explaining how they learn (Merriam et al., 2020). Houle (1961), through in-depth interviews with adult learners, categorized self-directed learning among adults into goal-oriented, learning- oriented, and activity-oriented types based on the motivation for participating in learning, providing a foundational framework for subsequent scholars' research on adult learning. In 1966, Tough first introduced the concept of "self-directed learning," whose connotation was further developed and expanded by Knowles. In 1975, Knowles published a seminal work on SDL, which is consideredthe most cited publication on SDL.

Since Knowles (1975), there has been a considerable effort to define and describe SDL. Currently, scholars tend to understand the essence of "Self-Directed Learning" from two perspectives: a process-oriented view and a personality trait view. Among them, the typical "process-oriented" perspective includes: Knowles posits that children are learners with a higher dependence, while adults are independent learners. This implies that adult learning does not rely predominantly on external guidance like that of children; instead, they can self-regulate, completing their learning based on self-direction. Knowles views individuals as autonomous and independent, which is both aprerequisite and foundation for adults' self-directed learning. He defines "self-directed learning" as:"In its broadest meaning, ‘self-directed learning’ describes a process in which individuals takethe initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material sources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes." Long (2000) sees self-directed learning not just as an outcome, but as a process where the learner is responsible for initiating, planning, implementing, and monitoring their learning. Additionally, many scholars from a psychological standpoint regard self-directed learning as a personality trait or inclination, a

"personality trait view": Wiley (1983) defines "Self-Directed Learning Readiness (SDLR)" as "the degree to which an individual possesses the attitude, abilities, and personality characteristics necessary for self-directed learning." Lounsbury (2009) and others argue that there is a logical relationship between self-directed learning and personality traits.

This study adopts the definition by Knowles (1975), positing that self-directed learning is a process in which learners, based on actual conditions, identify certain learning needs and, in accordancewith learning objectives, formulate relevant learning plans. Subsequently, they autonomously implement these plans and ultimately evaluate the learning outcomes.

Current research on Self-Directed Learning (SDL) spans multiple domains, including lifelong learning, intrinsic motivation, self-efficacy, self-regulation, blended learning, and deep learning. For instance, studies have demonstrated that SDL is a key characteristic of the capacity for lifelong learning, playing an essential role in students' academic and personal growth (Salleh et al., 2019). SDL not only fosters deep learning but also exhibits a significant correlation with academic achievement (Altinpulluk et al., 2023). This mode of learning relies on students' intrinsic motivation,self-efficacy, and their willingness to tackle challenges, with these factors collectively shaping the learning attitudes and methods of SDL. Research indicates that learners with high SDL skills are more likely to be active self-regulators, displaying significant differences from lower achievers in terms of learning strategies, awareness, preparation, time, resource utilization, and peer support (van der Graaf et al., 2022). Studies have confirmed a moderate positive correlation between SDL and intrinsic motivation, highlighting learners' intrinsic motivation as a crucial factor supporting SDL (Altinpulluk et al., 2023). Educational practices, such as flipped classrooms, effectively enhance students' engagement and SDL capabilities (Hsieh & Maritz, 2023). Additionally, learning styles impact students' academic performance and the amount of time invested in SDL, with multiple instructional guidance options provided by teachers further promoting certain aspects of students' autonomous learning (Ganji et al., 2022; Hsieh & Maritz, 2023).

In the modern educational landscape, the significance of Self-Directed Learning (SDL) is further emphasized. Research indicates that SDL plays a key role in the deep processing of knowledge and is correlated with learning outcomes and academic achievements (Lai et al., 2024). Additionally, pedagogical and instructional design methods have potential impacts on fostering the development of students' SDL capabilities within blended learning environments (Adinda & Mohib, 2020). Creative learning outcomes can be supported through SDL, and the attitudes and methods of SDL positively predict online learning engagement. This relationship is mediated by the perceived value of learning objectives (Sun et al., 2023).With the advancement of educational technology, research on Self-Directed Learning (SDL) has begun to focus on new trends in learning, such as Massive Open Online Courses (MOOCs) and home learning during the COVID-19 pandemic (Alhammadi, 2021; Altinpulluk et al., 2023). These studies not only explore the link between SDL and global educational reforms but also highlight the role of personal interest and self-regulation in various types of autonomous technology activities. Notably, personal interest is a significant predictor across all types of technological activities, while self-regulation primarily predicts instructional, informational, and social-oriented activities (Lai et al., 2024). This finding emphasizes the importance of focusing on both interest and self-regulation when promoting autonomous learning behaviors. However, excessive cognitive load, particularly when

cognitive capabilities are not yet mature, may only lead to superficial changes in knowledge rather than deep learning (Butcher & Sumner, n.d.). Therefore, educators need to consider this when designing and implementing self- directed learning activities to ensure that the activities not only stimulate students' interest but also do not exceed their cognitive load.

Based on the above discussion, self-directed learning is a key factor for student success, as it promotes deep learning and academic achievement. However, which factors facilitate deep learningduring the self-directed learning process and how students experience and achieve the deep learningprocess still require further study.

Deep Learning

Deep learning, as a significant topic in the field of education, has seen its understanding and definition evolve through various stages over time. From early studies to modern theoretical explorations, scholars from multiple perspectives have defined and interpreted deep learning, creating a rich series of theoretical frameworks and viewpoints. In 1976, Ference Marton and Roger Säljö first introduced the concepts of Surface Learning and Deep Learning. Through experimental research on students reading academic articles, they differentiated between two learning approaches:Surface Learning focuses on the superficial information and rote memorization of texts, whereas Deep Learning emphasizes understanding the deep meaning of texts, questioning the author's viewpoints, and connecting with one's knowledge and experience (Marton, & Säljö, 1976). Scholars gradually expanded on this concept. For example, John Biggs built on Marton's work to propose that deep learning involves high-level or active cognitive processing (Biggs, 1979). In "7 Powerful Strategies for Deep Learning," Eric Jensen and LeAnn Nickelsen further highlighted the multi-level processing in deep learning and the transformation in learners' thoughts, behaviors, or control during the learning process (Jensen, & Nickelsen, 2008). In China, research on deep learning began around 2005. Li Jiahao and others defined deep learning as the process of understanding new ideas and facts critically and integrating them into the existing cognitive structure (Ling, & Jiahao, 2005). Subsequently, scholars domestically and internationally conducted deeper research on deep learning, exploring and defining it from various angles, including learning methods, processes, and outcomes. Modern research on deep learning not only focuses on the depth of the learning process, emphasizing the transition from superficial memorization to deep understanding and creation, but also values the learning outcomes, namely the development of learners' problem-solving capabilities, metacognitive abilities, and creativethinking skills (Sando et al., 2023; Weng et al., 2023). Scholars like Julian Hermida and the National Research Council (NRC) in the United States emphasize deep learning as a continuous process of knowledge construction, aiding learners in solving practical difficulties and issues in social interactions (Hermida, 2014; Council, 2013). Canadian scholar Michael Fullan and others have proposed a new pedagogical perspective, suggesting that deep learning involves new types of learning partnerships between students and teachers, digital tools and resources, and deep learning tasks (Fullan, & Langworthy, 2014).

This study posits that deep learning is a learning process driven by intrinsic motivation, critically integrating and deeply processing information from multiple sources. It aims to foster the development of higher-order cognitive abilities—including application, analysis, evaluation, and synthesis capabilities (derived from Bloom's taxonomy)—to achieve

problem-solving and knowledge transfer. Furthermore, deep learning also emphasizes cultivating learners' core competencies, such as collaboration, communication, autonomous learning, perseverance in learning, critical thinking, and innovative thinking, to meet the complex demands of future society. Through this process, learners can profoundly understand the content and effectively apply knowledge in new contexts, thereby promoting comprehensive personal development on multiple dimensions.

Current research on deep learning in the field of education primarily focuses on the development of learning strategies, the application of technology and tools, and aspects such as student engagement and motivation (Aguiar-Castillo et al., 2021; Alhammadi, 2021; Fouché, 2024; Pereira & Wahi, 2021). For example, some studies are dedicated to exploring and verifying which learning strategiescan effectively promote deep learning, such as critical thinking, problem-solving abilities, and reflective learning (Nhat & Le, 2023; Weng et al., 2023). Moreover, with the widespread use of technology in education, researching how digital tools and online platforms can facilitate deep learning has become a hotspot. This includes exploring how blended learning, flipped classroom models, and gamified learning can support the deep learning process (An & Qu, 2021; Pereira & Wahi, 2021). There is also research aimed at how to enhance student engagement and intrinsic motivation during the deep learning process. This involves designing learning activities that stimulate students' curiosity and desire to explore, as well as enhancing students' self-efficacy and satisfaction with learning through self-directed learning strategies (Aguiar-Castillo et al., 2021; Pereira & Wahi, 2021). As the educational community's understanding of student autonomy and personalized learning needs deepens, more research emphasizes the critical role of autonomous learning in promoting deep learning, and how interdisciplinary approaches can facilitate deep learning, highlighting the integration of theory and practice, and the integration of knowledge across different disciplines (Parpala et al., 2022; Segú Odriozola, 2023). However, current research on the integration of deep learning and self-directed learning (SDL) is relatively insufficient. Although deep learning is widely considered a crucial pathway for fostering the comprehensive development of students, its potential in combination with SDL has not been fully explored. SDL emphasizes the learner's initiative and autonomy, aligning with the active participation and higher- order thinking skills emphasized in deep learning. Thus, further research is needed to effectively integrate these two modes of learning to optimize educational strategies and improve learning outcomes. Additionally, research should focus on how to design learning environments and tasks that stimulate students' intrinsic motivation and desire for autonomous learning, thereby promoting deep learning. This includes developing course content that aligns with students' interests and needs,providing rich learning resources, and creating learning communities conducive to exploration, communication, and collaboration. In summary, future research on deep learning needs to pay more attention to how to combine deep learning principles with self-directed learning strategies. By doing so, educators can better meet students' individualized learning needs, foster comprehensive development, and prepare them for success in the complex and changing social and work environments of the 21st century.

Theoretical Framework

Self-Determination Theory (Sdt)

Self-Determination Theory (SDT), proposed by Deci and Ryan, emphasizes three fundamental psychological needs: autonomy (a sense of control over one's actions), competence (a sense

of efficacy during activities), and relatedness (a sense of connection with others) (Ryan & Deci, 1985).This study chooses SDT as its theoretical foundation because SDT delves into the intrinsic mechanisms of motivation, particularly how meeting an individual's basic psychological needs can foster intrinsic motivation and positive behavioral outcomes. The three core psychological needs of SDT—autonomy, competence, and relatedness—provide crucial perspectives for understanding andpromoting Self-Directed Learning (SDL) and deep learning. By highlighting the importance of autonomy, competence, and relatedness, SDT helps explain why SDL can effectively enhance deep learning. Support for autonomy enhances students' intrinsic motivation, making them more actively engaged in the learning process, thus deepening their understanding and application of knowledge. Meanwhile, fulfilling the need for competence promotes a sense of achievement among students during the learning process, strengthening their willingness to explore and solve complex problems. The satisfaction of relatedness needs strengthens positive interactions between students and their teachers and peers, creating a supportive social environment for deep learning.

Metacognitive Theory

Metacognitive theory focuses on an individual's cognition, monitoring, and regulation of their own learning process. It comprises two main components: metacognitive knowledge (understanding one's own learning strategies and processes) and metacognitive skills (monitoring and regulating one's cognitive processes and learning strategies). Metacognitive abilities enable learners to effectively plan, monitor, and evaluate their learning, thus gaining better control over the learning process (Flavell, J. H., 1976). Guided by metacognitive theory, this study analyzes how autonomous learning activities can foster the development of students' metacognitive abilities, thereby supporting deep learning. By exploring how autonomous learning strategies (such as goal setting, self-monitoring, and reflection) help students enhance their cognition and regulation of theirown learning processes, the study reveals the specific impact of these strategies on promoting deep learning.

Self-Determination Theory and Metacognitive Theory together provide robust theoretical support for this study. SDT examines the impact of psychological needs satisfaction on motivation for deep learning, while Metacognitive Theory explores how self-monitoring and regulation of the learning process can enhance deep learning abilities. Together, they offer theoretical and methodological guidance for investigating the facilitative role of self-directed learning strategies in the deep learning process.

Research Questions

What is the interrelationship between Self-Directed Learning and Deep Learning?
During the process of Self-Directed Learning among university students, which factors are mostconducive to the occurrence of Deep Learning?
How do students experience and achieve Deep Learning within the context of Self-DirectedLearning?

Research Methodology

Through conducting a systematic literature review and meta-analysis, this study aims to collect, evaluate, and integrate evidence on the interaction between Self-Directed Learning and DeepLearning from existing literature, in order to identify and analyze key Self-Directed Learning conditions and factors that facilitate Deep Learning.

Sample Acquisition

To effectively retrieve target literature for this study, a precise title search was conducted in the Web of Science database using keywords "Self-Directed Learning," "Self-Regulated Learning," "Independent Learning," "deep/deeper learning," "deep approach," "deep processing," "deep strategies," "deep learner," with the literature timeframe set from January 1, 2020, to March 8, 2024. A total of 265,092 documents were obtained (Deep learning n=253,980, self-directed learning n=2,112). The Web of Science database was selected as the source of articles for this literature review because it is a renowned academic resource database, encompassing high-quality, peer-reviewed journal articles, conference papers, etc., from various fields. It is widely considered one of the essential academic resources for science, social sciences, arts, and humanities.

Sample Selection Criteria

To ensure the accuracy and reliability of the literature analysis results and to precisely present the interrelationship between Self-Directed Learning and Deep Learning, as well as the research situation regarding the facilitative role of Self-Directed Learning on Deep Learning, based on the research questions, this study established literature inclusion/exclusion criteria for the initiallyretrieved 265,092 documents as shown in Table 1. The first six criteria in Table 1 are common standards for selecting literature in systematic reviews, the seventh criterion restricts the research scope to higher education, the eighth criterion specifies the quality of the literature, excluding documents lacking a research question, rigorous research process, and clear research methods; the ninth criterion aims to focus the literature's research topic on the study of Self-Directed Learning and Deep Learning, excluding research literature whose focus does not align.

Table 1
Literature Exclusion/Inclusion Criteria

Number	Inclusion Criteria	Exclusion Criteria
1	English-language papers	Non-English papers
2	Empirical studies	Non-empirical studies
3	Full text available	Full text unavailable
4	Articles are journal papers	Reviews, conference papers, reports, etc.
5	Articles contain at least three pages	Posters, short papers, or briefs less than three pages
6	Article title appears only once	Duplicate titles
7	Research level is higher education	Research level is not higher education
8	Research includes a clear research question, method, and conclusion	Research lacks a clear research question, method, or conclusion
9	Research topics focus on Self-Directed Learning or Deep Learning	Research topics are not Self-Directed Learning or Deep Learning

Literature Screening Process

The literature selection process for this study follows the research approach of Systematic Reviews and Meta-Analyses (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA). This method requires a clear presentation of the process and reasons for

literature identification, screening, inclusion, or exclusion to enhance the accuracy of systematic review and meta-analysis reports. Based on this research approach, this study ultimately identified 39 papers that met the criteria to address the research questions of this study. The PRISMA flow diagram is shown in Figure 1and 2, and the table of included literature is presented in Table 2.

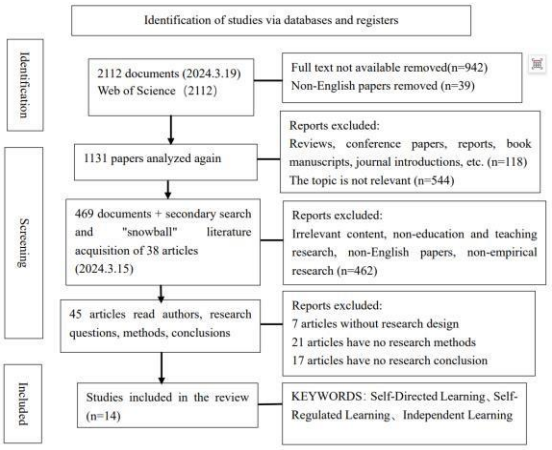

Fig.1 self-directed learning

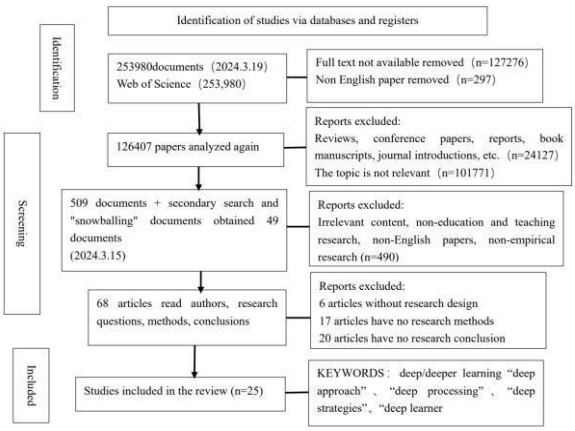

Fig.2 deep learning

Table 2
List of Included Documents

THEME	NUMBER OF DOCUMENTS
Deep learning	25
Self-directed learning	14

Data Analysis Process

The data analysis process of this study went through three stages, namely key information summary,dimensional analysis, and content analysis.

The first phase involved summarizing the key information of the literature. The method of content summary was utilized to distill the main content, research themes, findings, and contributions of the literature, allowing for a quick understanding of the core content and research focus, thereby laying the foundation for subsequent in-depth analysis. During this stage, the following tables were formed:Table 3 Basic Information of Self-Directed Learning Literature; Table 4 Key Information table of Self-Directed Learning Literature; Table 5 Findings and Contributions of Self-Directed Learning Literature; Table 6 Basic Information table of Deep Learning Literature; Table 7 Key Information table of Deep Learning Literature; Table 8 Findings and Contributions of Deep Learning Literature. Specific details of the tables are provided in the attachment.

The second phase involved dimensional analysis of the literature. Using thematic analysis, key concepts and themes were extracted and identified from the literature to explore what kind of relationship exists between SDL and deep learning, how SDL facilitates deep learning, and what arethe key factors and conditions in SDL that promote deep learning. Through the categorization and comparison of key concepts and themes appearing in the literature, a deeper understanding of the interaction and influence mechanisms between SDL and deep

learning was achieved. During this stage, the following tables were formed: Table 9: Analysis table of factors and conditions for self- directed learning environment to promote deep learning; Table 10: Analysis table of key factors for self-directed learning environment to promote deep learning.

The third phase is content analysis. During the content analysis phase, the focus is on exploringhow students experience and achieve deep learning within the process of Self-Directed Learning. The analysis at this stage aims to deeply understand students' learning experiences, the learning strategies they adopt, and how these strategies facilitate the achievement of deep learning. Content analysis, through a detailed examination of case studies, empirical research findings, and theoreticaldiscussions in the literature, distills key experiences and processes that contribute to deep learning. During this stage, the following tables were formed: Table 11: Table of Students' Self-Directed Learning Experiences and Strategies for Achieving Deep Learning, and Table 12: Table of Acievements of Deep Learning in the Process of Students' Self-Directed Learning.

Results and Discussion

What is the interrelationship between Self-Directed Learning and Deep Learning?

Key Processes in Self-Directed Learning Strategies and Environments that Facilitate Deep Learning Self-Directed Learning emphasizes the learner's active participation and self-management abilities, which directly support key processes in deep learning, such as active exploration, critical thinking, and the ability to integrate new knowledge with existing knowledge (Long, 2000). For example, in online learning environments, students facilitate deep understanding and application of knowledge by autonomously selecting learning resources, setting their own learning objectives, andmanaging their time (Sun et al., 2023). Research indicates that an individual's interest in learning topics and the tendency to pursue personal interests through learning are key drivers for engaging students in self-directed learning (Lai et al., 2024). Interest and intrinsic motivation are essential components of self-directed learning and equally critical for deep learning, as they can inspire students' curiosity and desire to explore, thereby facilitating the learning of complex concepts (Litzinger et al., 2005). Additionally, reflective learning activities in self-directed learning environments, such as learning logs and self-assessment, encourage students to deeply reflect on their learning processes and outcomes (Stephen & Rockinson-Szapkiw, 2021). This reflection not only helps students identify and correct misunderstandings in their learning but also promotes a deep understanding of knowledge and the formation of long-term memory. Research shows that environments supporting self-regulated learning behaviors are particularly important for deep learning (Evenhouse et al., 2023). For example, the blended learning environments that provide a mix of autonomous learning and teacher-guided learning, as well as the functionalities of online course platforms that support students' independent preparation and study, are effective conditions for promoting deep learning (Onah et al., 2020). In the process of self-directed learning, theeffective use of technology, such as online resources and Learning Management Systems (LMS), offers flexibility and convenient access to a wide range of information, thereby supporting students in deeply exploring knowledge according to their interests and needs, and facilitating the occurrence of deep learning (Fanshawe & Barton, n.d.).

Deep Learning, in Turn, Promotes the Practice and Development of SDL

The deep understanding and application of knowledge within the deep learning process can ignite learners' curiosity and thirst for knowledge, thereby enhancing their interest in exploring new knowledge. This sustained learning motivation is a key factor for the success of SDL (Hsieh & Maritz, 2023). Deep learning aids learners in building a more solid and systematic knowledge structure by fostering critical thinking, problem-solving abilities, and the application of knowledge (Weng et al., 2023). This efficient learning process can enhance an individual's self-directed learning capabilities, enabling learners to more effectively plan, monitor, and adjust their learning pathways (Ma, 2022). Reflective and evaluative activities in the deep learning process promote a profound understanding of one's learning process, including recognizing one's learning style, strengths, and areas for improvement (Nhat & Le, 2023). This self-reflection and evaluation capability is a core component of SDL, essential for learners to autonomously adjust their learning strategies (Fanshawe & Barton, n.d.). Through engaging in deep learning activities, learners can more flexibly adapt to complex and uncertain learning situations, selecting appropriate learning resources and strategies. This adaptability and flexibility are necessary conditions for implementing effective SDL (Evenhouse et al., 2023; Onah et al., 2020; Stephen & Rockinson-Szapkiw, 2021).

In summary, deep learning is not only a result of SDL but also provides strong support for the implementation of SDL. Through deep learning, learners can cultivate a more proactive, reflective, and collaborative learning attitude, thereby further strengthening and optimizing the process of self-directed learning.

The Potential Connection Between Self-Directed Learning (SDL) and Deep Learning

The reciprocal relationship between Self-Directed Learning (SDL) and Deep Learning indeed formsthe core of their interaction, but there are also other potential connections between the two. These connections are not limited to direct mutual promotion but also include the wider educational context and the impact on personal development levels.

Common Promoters of Cognitive Development: Both SDL and deep learning are committed to advancing learners' cognitive development, especially in promoting higher-order thinking skillssuch as critical thinking, analysis, and evaluation. The development of these skills aids learners in thinking and making decisions more independently and effectively when faced with diverse and complex problems (Altinpulluk et al., 2023; Hsieh & Maritz, 2023; Nhat & Le, 2023; Saqr et al., n.d.-a).

The Foundation of Lifelong Learning: Both SDL and deep learning are essential components of lifelong learning. With the acceleration of knowledge renewal and changes in career paths, individuals must continuously learn and adapt to new knowledge and skills. SDL provides autonomy and proactivity in learning, while deep learning ensures the quality and durability of learning. Together, they form a solid foundation for lifelong learning (Alhammadi, 2021; Geitz et al., 2023; Salleh et al., 2019; Saqr et al., n.d.-a).

The Interplay of Affect and Motivation: The sense of achievement and interest in the learning content generated during the deep learning process can significantly enhance learners' intrinsic motivation, which is crucial for the sustainability and effectiveness of SDL.

Simultaneously, the enhancement of self-efficacy in SDL can, in turn, strengthen the learners' motivation to engage in deep learning (Altinpulluk et al., 2023; Hsieh & Maritz, 2023; Lai et al., 2024; Nhat & Le, 2023).

What factors or conditions best facilitate the occurrence of deep learning during self-directed learning?

To address this issue, the research conducted a thematic analysis of the literature, identifying key concepts and themes, and consolidated this critical information into Table 9. Based on the information in the table, the study further merged related themes to reduce redundancy and enhance conceptual clarity, thereby enabling more effective identification and application of these factors. The consolidation of themes resulted in Table 10: Analysis table of key factors for self-directed learning environment to promote deep learning. Table 10 clearly displays the key factors that facilitate deep learning in the process of self-directed learning, categorized into internal factors and external conditions. Internal factors include self-regulation and self-directed learning capabilities, interest and motivation, metacognitive skills, as well as reflection and evaluation. External conditions involve the effective use of technology, interactive learning environments, innovative teaching models, and contextual engagement and gamification.

Table 10

Analysis Table of Key Factors for Self-Directed Learning Environment to Promote DeepLearning

Dimensions	Theme	Explanation
Internal factors	Self-regulation and Self-directed Learning Abilities	This theme emphasizes students' active participation in their ownlearning process, including setting learning goals, managing learning resources and time, and self-monitoring learning progress. This ability enables students to learn independently according to their own needs and interests, adapt to different learning situations, and effectively improve learning results.
	Interests and Motivations	This topic focuses on the role of students' personal interests and intrinsic motivation in the learning process. A high degree of personal interest and intrinsic motivation can inspire students toexplore learning content in depth and actively participate in learning activities, thereby promoting deep understanding and long-term knowledge retention.
	Metacognitive Skills	Involves students' ability to understand, monitor and adjust theirown cognitive processes. By improving metacognitive skills, students can plan, execute and evaluate their own learning strategies and processes more effectively, thereby improving learning effectiveness and autonomous learning capabilities.

	Reflect and Evaluate	Emphasis is placed on students improving learning efficiency by reflecting on and evaluating their own learning processes and outcomes. This includes self-assessment, reflective writing, etc., to help students identify and consolidate learning outcomes, discover and solve learning problems, and promote the connection of new and old knowledge.
external conditions	Effective use of Technology	Focuses on how technology tools and online resources can be used to support and enhance learning. Effective use of technology can support deep learning by providing personalized and collaborative learning opportunities, making learning more flexible and interactive.
	Interactive Learning Environment	Focus on creating a supportive and interactive learning environment that includes teacher-student interaction, peer learning, and interaction with the learning platform. Such an environment encourages students to actively participate, promotes social learning and knowledge co-construction, thereby deepening learning and understanding.
	Innovative Teaching	Covers the use of innovative teaching designs and course structures, such as project-based learning (PBL), problem solving,etc., to provide authentic and challenging learning experiences. These methods encourage students to actively explore and apply knowledge and promote the development of critical thinking and innovation abilities.
	Situational Engagement and Gamification	Improving students' emotional and behavioral engagement through situated learning and gamification strategies is highlighted. These strategies promote deep learning and effective application of knowledge by creating an attractive learning environment and practical opportunities that enhance students' learning motivation and engagement.

Internal factors

Self-Regulation and Self-Directed Learning Abilities: Self-regulation and self-directed learning abilities are widely regarded as key elements for deep learning, capable of effectively facilitating the occurrence of deep learning among students. For example, the paper by Stephen & Rockinson- Szapkiw (2021) enhances students' self-regulation and self-direction abilities through the design and implementation of a first-semester seminar course, particularly emphasizing the role of reflective activities (such as learning logs). Through

continuous participation and reflection on the learning process, it promotes a deep understanding and application of knowledge. Similarly, the paper by Onah et al. (2020), by embedding MOOC platforms, promotes autonomous learning and self-regulated learning skills among undergraduate students, demonstrating how self-directed learning can facilitate deep learning within the context of integrating traditional and modern educational backgrounds.

Interest and Motivation: Individual interest and intrinsic motivation, as significant factors driving deep learning, positively promote students' deep learning. For instance, Lai et al. (2024) explored how individual interest and self-regulation interact and affect the process of autonomously using technology for language learning, highlighting the pivotal role of individual interest and intrinsic motivation in promoting deep learning. Hsieh & Maritz (2023) found that flipped teaching, by increasing the proportion of students' autonomous pre-class learning, enhanced students' intrinsic and extrinsic motivation, thereby fostering the enhancement of autonomous learning abilities,demonstrating the role of motivation in the occurrence of deep learning.

Metacognitive Skills: Students' metacognitive awareness is seen as a key factor in deep learning. Metacognitive abilities, including cognitive monitoring and self-regulation, enable students to understand their own learning processes, identify learning obstacles, and effectively apply learning strategies (Moonen-Van Loon et al., 2022). The use of blended learning environments and MOOC platforms in the study by Onah et al. (2020) promoted autonomous learning and self-regulated learning skills, reflecting the role of metacognitive skills in planning, executing, and evaluating learning strategies. The research by Hua et al. (2023) on the use of Learning Management Systems (LMS) supported self-monitoring and progress evaluation, emphasizing the importance of metacognitive skills in enhancing deep learning and autonomous learning abilities.

Reflection and Evaluation: Research highlights the importance of promoting deep learning through reflective activities such as learning logs and self-assessment. These methods assist students in reflecting on their learning processes and strategies, constituting a key component of deep learning. Stephen & Rockinson-Szapkiw (2021) facilitated the development of self-regulation and self-direction abilities among students by requiring them to engage in reflective activitieswithin learning logs, promoting deep understanding and application of knowledge. Fanshawe & Barton (n.d.) utilized text mining technologies to assist in feedback interpretation, fostering students' self-assessment progress and the formulation of new learning goals and strategies, emphasizing the role of reflection and evaluation in deep learning.

External factors

Effective Use of Technology: Technology plays a positive mediating role between autonomous learning and lifelong learning. Interaction, sharing, and collaboration activities conducted through social networks can promote deep understanding of learning and knowledge among students (Salleh et al., 2019). In the current educational context, technological literacy and the effective use ofonline resources are considered key to promoting deep learning (Lai et al., 2024). The interplay between individual interest and self-regulation in the process of using technology for language learning demonstrates how technology supports personalized and

deep learning (Salleh et al., 2019). Autonomous informal learning with online resources emphasizes the role of technology in providing a selective and free learning environment, fostering deep learning.

Interactive Learning Environments: Diverse and interactive learning resources, such as the flipped classroom model, increase students' engagement and motivation, which are crucial for deep learning. Students' perceptions of the learning environment, including the accessibility of resources,the supportiveness of platforms, and interactions with teachers and peers, are vital for deep learning (Geitz et al., 2023; Thompson & Lake, 2023). Evenhouse et al. (2023) showed that blended learningenvironments provide a variety of learning resources and support self-regulated learning behaviors, illustrating the importance of interactive learning environments in the occurrence of deep learning. Activities designed through online collaboration, project-based work, and participation in social media discussions (Salleh et al., 2019) emphasize the role of interactive learning environments in promoting learners' deep understanding and application of knowledge.

Innovative Teaching Models: Innovative teaching encompasses the adoption of novel instructionaldesigns and course structures, such as Project-Based Learning (PBL) and problem-solving, to provide authentic, challenging learning experiences. These methods encourage students to actively explore and apply knowledge, fostering the development of critical thinking and innovative capabilities. Tuononen et al. (2023) show that Case-Based Learning (CBL) offers real-life learning experiences, encouraging students to actively explore and apply knowledge, highlighting the role of innovative teaching in promoting deep learning. Geitz et al. (2023) illustrate that Design-Based Education (DBE), by providing a learning environment aligned with professional fields and emphasizing the integration of practical and theoretical knowledge, supports students' deep learning.

Situational Engagement and Gamification: Situational engagement and gamification highlight the enhancement of students' affective and behavioral involvement through contextual learning and gamification strategies. These strategies, by creating engaging learning environments and practical opportunities, enhance students' motivation and sense of participation, thereby fostering deep learning and the effective application of knowledge. Salleh et al. (2019) emphasize the importance of individual interest in learning topics as the main driver of deep learning and affective engagement through autonomous informal learning with online resources. Altinpulluk et al. (2023) show a positive relationship between self-directed learning and levels of intrinsic motivation within the MOOC environment, highlighting the role of situational engagement and gamification strategies in enhancing motivation and deep learning.

These internal factors and external conditions synergistically contribute through various mechanisms to facilitate the occurrence of deep learning. Such mechanisms include enhancing students' motivation for learning, providing a wealth of learning resources, fostering communication and collaboration among students, as well as developing critical thinking andproblem-solving skills. By integrating these elements, it is possible to create a rich and diverse learning environment that promotes deep learning among students.

How do students experience and achieve deep learning within the process of self-directed learning?

Before answering how students experience and achieve deep learning within the process of self- directed learning, a content analysis of the literature is first conducted to summarize and categorize specific experiences of students during self-directed learning and how these experiences facilitate the achievement of deep learning. This includes the deep learning strategies adopted, and how specific learning experiences promote a deep understanding and application of knowledge. Detailed content is shown in Table 11: Table of Students' Self-Directed Learning Experiences and Strategies for Achieving Deep Learning. Further content analysis of the literature is then conducted to delve deeper into the outcomes of deep learning achieved through the strategies or activities implemented during the process of self-directed learning. This analysis explores how learning strategies or activities specifically impact students' outcomes in deep learning, including changes at the cognitive,emotional, and behavioral levels. Detailed content is shown in Table 12: Table of Acievements of Deep Learning in the Process of Students' Self-Directed Learning.

Through thematic analysis of the content of the tables, it was discovered that students achieve deep learning during the process of self-directed learning through a series of strategies and activities. These can be summarized as reflection and self-regulation, enhancement of intrinsic and extrinsic motivation, utilization of technology and social media, Problem-Based Learning (PBL) and interdisciplinary collaboration, as well as the cultivation of metacognitive awareness.

Reflection and Self-Regulation

Reflection and self-regulation are key mechanisms for achieving deep learning in the process of self-directed learning. By writing learning logs and engaging in reflective writing activities, students can not only examine and evaluate their learning methods, understanding processes, and their effects but also identify and overcome obstacles in learning. This continuous self-monitoring and adjustment process not only directly influences the depth and efficiency of learning but also fosters the development of students into independent and self-driven learners with long-term learning outcomes. Research by Stephen & Rockinson-Szapkiw (2021) indicates that participationin high-impact teaching practices, such as learning logs and reflective writing, can significantly enhance students' self-regulation abilities, promoting a deep understanding and application of knowledge. Fanshawe & Barton (n.d.)'s study, which supported doctoral students' self-directed learning through the use of a Learning Management System (LMS), found that regular reflection and self-monitoring activities help students deepen their understanding of academic research, improve academic writing and research skills, and emphasized the importance of self-regulated learning abilities for deep learning. Through the integrated use of reflective activities such as learning logs and reflective writing, along with the cultivation of self-regulated learning abilities, students can achieve a deeper level of knowledge understanding and application in the process of self-directed learning. The development of these strategies and skills is beneficial not only for current learning tasks but also lays a solid foundation for students' lifelong learning.

Enhancement of Intrinsic and Extrinsic Motivation

The enhancement of intrinsic and extrinsic motivation is crucial for facilitating deep learning in the process of self-directed learning. By increasing learning motivation, students can

engage more actively in learning, thereby achieving a deep understanding and application of knowledge.

The study by Hsieh & Maritz (2023) elaborates on how flipped teaching enhances students' active participation in the classroom, thereby increasing students' intrinsic motivation and autonomous learning abilities. The flipped classroom model enables students to apply theoretical knowledge in practice, enhancing the practical significance and value of learning. Research by Aguiar-Castillo et al. (2021) demonstrates that integrating gamification elements into the learning process in higher education can significantly increase students' interest and engagement in learning. Gamified learning, by providing immediate feedback and rewards, stimulates students' extrinsic motivation, making the learning process more attractive and meaningful.

Utilization of Technology and Social Media

The use of social media platforms and online learning resources offers students opportunities for interaction and collaboration, providing access to a broad range of information resources, and engaging in discussions and project work, which promotes a deep understanding of knowledge and the development of critical thinking skills (Salleh et al., 2019). This study explores how social networking sites serve as tools for self-directed learning, facilitating individual and collectivelearning, enhancing learners' control over their learning processes, and increasing the interactivity and collaboration of learning (Alhammadi, 2021). The paper analyzes how, during the COVID-19 pandemic, learning quality was maintained and enhanced through online learning tools and platforms, especially social media. In remote learning environments, the effective use of technology and social media is crucial for maintaining student engagement, facilitating communication and collaboration, and supporting deep learning.

In light of the above discussion, the utilization of technology and social media significantly facilitates deep learning in the process of self-directed learning. By providing rich learning resources, promoting interactive collaboration, and supporting critical thinking, technology and social media enable students to more effectively grasp complex concepts and cultivate the capabilities and attitudes necessary for lifelong learning. The successful implementation of this learning model requires educators and learning platforms to offer appropriate guidance and support to ensure the effective use of learning resources and the efficient organization of learning activities.

Problem-Based Learning (PBL) and Interdisciplinary Collaboration

Through tackling real-world problem challenges, students collaborate in multidisciplinary teams to apply and integrate interdisciplinary knowledge, which not only enhances problem-solving capabilities but also promotes deep learning and understanding (Geitz et al., 2023). This research underscores the importance of PBL and interdisciplinary collaboration within a Design-BasedEducation (DBE) environment. The DBE environment, by incorporating real-world problems and multidisciplinary knowledge, fosters students' deep learning, particularly showing significant advantages in promoting students' innovative and critical thinking (Saqr et al., n.d.-b). This study indicates that effective learning strategies, especially when applied in a PBL environment, are crucial for facilitating deep learning. By transferring and applying

these strategies in different learning contexts, students can better adapt to PBL environments, fostering the integration and application of interdisciplinary knowledge.

In summary, Problem-Based Learning (PBL) and interdisciplinary collaboration provide an ideal learning environment for students, where the resolution of practical problems promotes deep understanding and application of knowledge. This approach not only fosters students' criticalthinking and problem-solving skills but also enhances their collaboration and communication skills,serving as an effective means for deep learning.

Cultivation of Metacognitive Awareness

Through metacognitive activities, students learn how to plan their learning process, monitor their understanding and learning outcomes, and evaluate the effectiveness of their learning strategies, thereby managing and directing their learning more effectively. The cultivation of metacognitive awareness is a core component of deep learning because it involves students' cognition and regulation of their own learning processes, including setting goals, selecting strategies, monitoring progress, and reflecting on learning outcomes. Through metacognitive activities, students can not only identify and utilize effective learning strategies but also adjust their methods when encountering difficulties to ensure the achievement of learning objectives.

Tuononen et al. (2023) explored the role of metacognitive awareness in facilitating deep learning. The study found that cultivating students' metacognitive awareness significantly enhances their learning outcomes, as students learn how to effectively plan, monitor, and regulate their learning processes. van der Graaf et al. (2022) emphasized the importance of metacognitive activities in self- regulated learning. By implementing cognitive and metacognitive activities to control the learning process, students can better achieve learning objectives, demonstrating how metacognitive activities support key processes of deep learning.

Through the aspects mentioned above, students can experience and achieve deep learning in the process of self-directed learning, not only making progress in the accumulation and application of knowledge but also significantly improving in the depth of thought, criticality, and innovative capabilities.

Educational Practice Recommendations

Teaching Strategies and Methods

Reinforce Reflection and Self-Regulation Mechanisms: Incorporating regular reflective and self-assessment activities into course design, such as learning logs, project reflection reports, and self- assessment questionnaires, can help students engage in more effective self-regulation and reflection during self-directed learning, thereby promoting a deep understanding and application of knowledge.

Enhance Students' Intrinsic and Extrinsic Motivation: Teachers can adopt various teaching strategies based on the characteristics of the teaching content to motivate students' extrinsic motivation, while ensuring that learning activities are connected to students' personal

interests and career goals to enhance intrinsic motivation. The enhancement of motivation helps increase students' enthusiasm and curiosity for learning, which is crucial for deep learning.

Promote Problem-Based Learning (PBL) and Interdisciplinary Collaboration: Teachers can design PBL projects centered around real-world challenges, encouraging students to engage in interdisciplinary collaboration and autonomously seek solutions, providing resources and support when necessary, to cultivate students' self-directed learning awareness and deep learning abilities.

*Cultivate Metacognitive Awareness:*Teachers can instruct students on how to effectively plan, execute, monitor, and adjust their learning through relevant courses and activities. Students are encouraged to apply these skills to enhance the effectiveness of self-directed learning and deep learning.

Adopt Innovative Teaching and Assessment Methods: Develop and implement innovative teaching methods and assessment strategies, such as project-based learning, contextual learning, and flipped classrooms, to promote students' deep learning. The design of assessment methods should consider students' self-directed learning experiences and deep learning outcomes, ensuring that assessment methods accurately reflect students' learning progress and achievements.

Learning Environment and Support

Effectively Utilize Technology and Social Media: Actively integrate technological tools and social media platforms to support the autonomy, collaboration, and interactivity of learning. Provide training and guidance to help students effectively use technological tools for information retrieval, knowledge sharing, and collaborative learning.

Create Supportive and Interactive Learning Environments: Build an open, supportive, and interactive learning environment that encourages effective communication and collaboration amongstudents and between students and teachers. Utilize online discussion boards, peer reviews, and group projects to foster this interaction.

By implementing the above recommendations, educators can more effectively support students in achieving deep learning during the process of self-directed learning, promote students' personal and professional development, and lay a solid foundation for students' lifelong learning journey.

Conclusion

In this systematic literature review on the role of Self-Directed Learning (SDL) in facilitating the deep learning process, a total of 39 studies were analyzed to reveal the function of SDL indeepening students' understanding and application of knowledge. The conclusion of this study summarizes the interaction between SDL and deep learning, the key conditions for facilitating the occurrence of deep learning, and how students achieve deep learning during the SDL process.

Firstly, self-directed learning is identified as a key strategy for fostering deep learning, particularly in enhancing student engagement, motivation, and personalized learning. SDL encourages students to choose their learning paths based on their interests, needs, and goals. This autonomy and initiative are foundational for deep learning. Through self-regulated learning strategies, the development of metacognitive awareness, and reflection on the learning process, students can more effectively plan, monitor, and adjust their learning activities, promoting a deep understanding and application of knowledge.

Secondly, this study identifies key conditions that facilitate the occurrence of deep learning among university students in the context of self-directed learning, from two dimensions: internal factorsand external conditions. These include the utilization of technology and online resources, interest and motivation, metacognitive skills, self-regulation, and the application of assessment and feedback mechanisms. These conditions provide the necessary support and resources for students' deep learning, aiding them in achieving deep learning within a self-directed learning environment.

Finally, students experience and achieve deep learning in the SDL process by adopting autonomous learning strategies, reflecting and evaluating their learning processes, enhancing learningmotivation, effectively utilizing technology and media. These strategies and activities foster the development of students' critical thinking, problem-solving abilities, and innovative thinking, layinga solid foundation for their future academic and professional careers.

In summary, self-directed learning plays a crucial role in promoting deep learning. By providing students with a supportive learning environment, rich resources, and positive interaction opportunities, educators can foster students' self-directed learning abilities, thereby deepening their understanding and application of knowledge. With the continuous advancement of educational technology, the integration of self-directed learning and deep learning will offer students more personalized and flexible learning opportunities, further promoting their holistic development.

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