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Study time allocation in self-regulated learning: A metacognitive perspective and theoretical advances

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Abstract: This review explores the theoretical foundations and recent advances in study time allocation (AST) from a metacognitive perspective. It traces the conceptual pathway from metacognition to self-regulation and ultimately to self-regulated learning (SRL), highlighting key models such as discrepancy reduction, the region of proximal learning, and agenda-based regulation. Findings show that effective study time allocation relies on accurate monitoring and strategic control, yet learners often do not allocate time optimally, especially under time constraints or inaccurate self-assessment. Factors like item difficulty, reward structure, motivation, and learning goals interact to shape AST decisions. Recent research underscores the need to test whether learners' strategies truly enhance memory performance in real contexts and how online learning environments affect self-regulation. Future directions call for interdisciplinary integration with decision-making and economics, clarifying the role of learning strategies, and promoting practical interventions to improve monitoring accuracy and self-regulation skills.
Keywords: *Learning strategies, Memory monitoring, Metacognition, Self-regulated learning, Study time allocation.*

1. Introduction

1.1. Origins of Study Time Allocation Research: Two Pathways

1.1.1. Metacognition

When we think, speak, argue, solve problems, or even just search for the right words in a conversation, we continuously monitor our own thinking. We evaluate it, judge it, and sometimes even attempt to influence it. Rarely do we rest in the moment without engaging in metacognition, which means thoughts about one's own thoughts and cognitions [1]. Flavell defined the concept of metacognition as thinking about thinking. This is a crucial component of individuals' cognitive activities.

1.1.2. Metacognitive Monitoring and Self-Regulation

Most researchers agree that metacognition has at least two functions. One function is to monitor the current state of any cognitive activity we are engaged in Dunlosky and Metcalfe [2] the other is to control our own cognition. Monitoring and control are closely intertwined. Whether we engage in metacognitive control and how we attempt to regulate cognition often depends on the results of metacognitive monitoring [3].

Although Flavell laid the modern foundation for metacognition, he was not its only conceptual contributor. For example, Baker and Brown [4] divided metacognition into two distinct parts: knowledge about cognition (monitoring) and self-regulation (SR) mechanisms centered on monitoring. Self-regulation mechanisms include checking outcomes, planning, monitoring effectiveness, testing, revising, and evaluating strategies [4].

In sum, self-regulation is the implementation and manifestation of metacognitive control. These two concepts exist at the same hierarchical level within the structure of metacognition.

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1.1.3. Self-Regulated Learning

Growing attention to self-regulation (SR) and metacognitive monitoring and control in academic contexts seems to have directly contributed to the emergence of the term self-regulated learning (SRL). Self-regulated learning emerged in the 1980s and gained prominence in the 1990s [5]. Study time allocation (study time allocation or allocation of study time, AST) is a key component of self-regulated learning.

Thus, the structural pathway from metacognition, to metacognitive monitoring and self-regulation, to self-regulated learning, and finally to study time allocation has become well established.

1.1.4. Procedural Metamemory and Memory Control

In addition to the pathway above, there is another structure linking metacognition to study time allocation. From the perspective of cognitive processes, metacognition can be divided into metamemory, metathinking, and others. Metamemory itself can be divided into declarative metamemory and procedural metamemory.

Declarative metamemory refers to knowledge about metamemory; procedural metamemory, also known as memory monitoring and control, primarily investigates the supervision and regulation of one's own objective memory, and it is the core of metamemory development research. Memory monitoring includes memory monitoring and memory control.

Memory monitoring refers to receiving information from objective memory and forming judgments about the difficulty of the memory tasks, the level of one's own memory performance, and the retrieval status, in order to understand the state of objective memory. Specifically, this includes prospective monitoring and retrospective monitoring. The former occurs before retrieval behaviors, while the latter occurs after retrieval behaviors. Prospective monitoring includes ease of learning (EOL), which estimates the difficulty of the memory task, and judgment of learning (JOL), which evaluates the level of memory performance. Retrospective monitoring includes judgment of confidence (JOC), assessing the accuracy of retrieval results, and feeling of knowing (FOK), evaluating the likelihood of reproducing content that was not retrieved.

Memory control is the regulation and control of objective memory based on the results of memory monitoring to effectively achieve memory goals.

The core of memory control is study time allocation (AST), which means allocating subjective resources to different learning contents based on task requirements. It should be noted that effective study time allocation is based on accurate memory monitoring. This theoretical framework introduces study time allocation from the research on metamemory control.

1.2. Study Time Allocation

Study time allocation (study time allocation or allocation of study time, AST) is an indicator of how learners allocate their attention and subjective effort, reflecting their understanding of the task and their ability to engage selectively [6].

Study time allocation includes decisions about what to study, in what order, for how long, and when to terminate studying. The first two decisions relate to item selection, while the latter two involve self-paced learning [7].

All study time allocation decisions involve monitoring and control [8]. That is, when people regulate their study time, they first monitor their study conditions (such as task difficulty and available study time), then evaluate their learning goals. Based on this, they decide what to study, how to study, for how long, and then accordingly control their study behaviors. While studying, individuals may further monitor their ongoing learning and adjust their control behaviors in the same way [7].

Learning is a broad term; in some contexts, self-regulated study time allocation may even include learning plans, how to allocate study activities, how to learn (meaning learning strategies and strategy selection), and many other components [9]. In other cases, SRL specifically refers to how people allocate their study time, including learning decisions such as what to study, in what order (item selection decisions), and for how long and when to stop studying (self-paced study decisions). The current research review focuses on the latter, narrower definition of learning [7].

1.3. The Significance of Studying Study Time Allocation

1.3.1. The Purpose of Study Time Allocation for Individuals

Why do individuals make study time allocation decisions? This is the most fundamental question at the origin of study time allocation research. Different time pressures and learning goals may lead to different emphases.
This can be summarized in two main goals.

First, to achieve objectively better memory performance and thus reach learning goals. In this context, learners have clear and fixed memory goals. Learners allocate time to task items in order to achieve better memory outcomes, that is, to raise their memory level from a lower to a target level. Second, to achieve higher learning efficiency, meaning to gain more benefits in a shorter time. These benefits include considerations of item difficulty, the level of memory required for items, item value, and so on. In this context, learners may adjust the memory level goals for items at any time based on monitoring. Time and goal flexibility for individual tasks are greater and more variable. The emphasis and context differ for these two goals. More experimental contexts tend to focus on the first goal, while more real-world contexts tend to emphasize the second.

If we ignore the process and look only at the results, the benefits of individuals' study time allocation behavior can be assessed in two dimensions: one is better memory performance, and the other is shorter time.

1.3.2. Broader Impact

Impact on learning and education. In recent years, self-regulated learning has become a key concept in the field of education. It plays a central role in influencing learning and achievement both inside and outside of school. The self-regulatory aspects of learning have significant effects on the effectiveness of students' learning efforts and educational achievement [10].
Impact in broader fields. The training effects of metacognition in any cognitive activity have broad transferability. Such training effects are naturally not confined to a specific field but can be widely transferred and applied to other domains. Moreover, self-regulation research has become an important topic in many areas of theoretical psychology. Over the past few decades, applied psychology, education, public health, and industrial sectors have increasingly recognized that goal-directed behavior is vital for individual and collective well-being, that goal-directed self-regulation can be improved, and that the impact of factors threatening self-regulation can be reduced. This awareness stems from numerous studies showing a close relationship between individuals' self-regulation strategies and various indicators of adaptive success. Researchers agree that to adopt and maintain effective self-regulation strategies, individuals must bear heavy demands and responsibilities. In recent years, there has also been growing recognition that to develop effective self-regulation, the organizations and communities in which people live, learn, and work must also share in these demands and responsibilities [11].
Researchers in the three main domains of self-regulation research, learning and development, health, and work, believe that the self-regulation processes they study are crucial for the development and maintenance of outcome variables relevant to their respective environments [11].

2. Theoretical Development

2.1. From Experimenter-Paced to Self-Paced Study

In the process of learning, researchers have examined different conditions to determine whether the pace and rhythm of learning should be controlled by the learner or by external factors.

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2.1.1. Experimenter-Paced Study

Initially, researchers conducted experiments under the condition of experimenter-paced study, meaning that the experimenter determined the pace, speed, and whether to continue learning. In this situation, learners could not control their own study time allocation.
In Masur, et al. [12] conducted a classic study investigating the development of children's study time allocation ability. Using pictures as materials, he asked first- and third-grade children and adults to study and recall, then required them to choose half of the items for restudy. The aim was to examine what types of items individuals of different ages would select for restudy. The results showed that third-grade children and adults were more likely to choose items they had failed to recall for restudy, whereas first-grade children displayed randomness in selection, with recalled and unrecalled items being equally likely to be chosen. A replication by Voss [13] confirmed Flavell's findings.
In this type of study, further learning is constrained by external arrangements. Regardless of whether learners wish to continue studying, they must select items for additional study, and both the study time and pace are pre-arranged by the experimenter. This to some extent deprives learners of their initiative and diverges significantly from real learning contexts.

2.1.2. Shift to Self-Paced Study

As a result, researchers began to investigate self-paced study, in which learners decide for themselves the pace, speed, rhythm, and when to stop studying.

Compared with experimenter-paced conditions, learners under self-paced conditions are in a more proactive state. Theoretically, through self-regulated study involving study time allocation, if learners can accurately direct their cognitive resources to items that require more attention, proper study time allocation should make learning and memory more efficient.

Research has shown that under conditions of accurate metacognitive monitoring and strategy selection, participants who control their study time allocation outperform groups who do not control their study time and study at a fixed pace [14].

2.2. Mechanisms of Study Time Allocation

2.2.1. Discrepancy Reduction Model

Dunlosky and Thiede [10] argued that individuals primarily select study items based on their perceived difficulty. They proposed the discrepancy reduction model to explain how individuals choose items to study. This model posits that individuals judge their level of mastery, compare it to an expected standard, and target the content with the largest gap between their current level and the standard for further study. Since more difficult items tend to have larger discrepancies from the standard, individuals will preferentially select more difficult items to reduce this gap [10].

2.2.2. Hierarchical Model of Self-Regulated Study

The discrepancy reduction model cannot explain how individuals select study items under different task goals and time constraints. For example, research by Thiede and Dunlosky [15] found that when task goals are high, participants tend to choose more difficult items, whereas for lower goals, they select easier items [15].

To address this, they proposed the hierarchical model of self-regulated study, which indicates that when individuals have a relatively low overall goal, they will prioritize restudying content they have already mastered to a greater extent rather than poorly mastered content [15].

2.2.3. Region of Proximal Learning Hypothesis

In Son and Metcalfe [16] examined how people's memory monitoring influences subsequent study time allocation decisions. They specifically explored how participants allocate study time under different time pressures and material lengths. They found that when participants did not have enough time, they allocated more time to easier items, especially when expecting a test. When the material was shorter,

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participants allocated more time to difficult items. Under high time pressure, people preferred to study easier items, whereas under moderate time pressure, no clear tendency was found for time allocation between easy and difficult items.

Metcalfe and Kornell [17] proposed the Region of Proximal Learning (RPL) hypothesis. This hypothesis emphasizes two important components of study time allocation controlled by different metacognitive indicators. The first component is selection, further divided into two stages: deciding whether to study and determining the priority order of items. If people's judgments of learning (JOLs) are sufficiently high and they believe they have mastered the item, they choose not to study it. If they decide to study, the order is from what they believe is almost known to what is more difficult (from high JOL to low JOL). The second element is persistence, emphasizing the rule for when to stop studying an item once begun. Their research suggests that people use a process-oriented metacognitive marker that had not been previously explored: their judgments of the rate of learning (jROLs) to decide when to stop. When learning progresses rapidly and jROL values are high, they continue to study. When jROL approaches zero, their subjective assessment indicates that learning has stagnated, prompting them to stop. Their study presented eight new experiments supporting this model [17]. The RPL model assumes that people first attempt to learn items they know best. Among unknown items, they rank them subjectively from easiest to hardest. Once they begin studying an item, they must decide when to give up and move to another. The model suggests that as long as people feel they are still learning, they will continue to devote study time to that item, but when they believe learning is no longer yielding returns, they will stop [17].

2.2.4. Agenda-Based Regulation Model

Some studies have shown that JOLs and study time allocation are influenced by item difficulty [18, 19]. However, other studies have found inconsistent results. When instructions were given that remembering an item would earn one point and participants were told to get as many points as possible, they prioritized easier items and gave them higher JOLs [20]. When difficult items had higher value, individuals prioritized difficult items and allocated more study time to them, with JOLs also guided by value [18]. To address this controversy, Ariel, et al. [21] introduced reward structure, including item value and testing probability, to examine its effect on study time allocation for items of varying difficulty. They found that regardless of whether processing was easier or harder, individuals chose items based on testing probability, prioritizing those with higher probability. When testing probability was replaced with item value, the results were the same, indicating that individuals select items based on value.

These studies indicate that when items differ in both difficulty and reward structure, learners do not prioritize difficulty but rather rely on the reward structure when making JOLs and item selection. This suggests that reward structure has a greater influence on JOLs and study time allocation than item difficulty. Based on this, the Agenda-Based Regulation Model (ABR) was proposed to explain how learners construct an agenda after integrating item difficulty and value, which then guides study time allocation [21, 22]. The model suggests that individuals integrate learning conditions such as task requirements to construct a study agenda and continuously adjust their study behavior accordingly. Sufficiently high reward expectations can override difficulty as the dominant factor in agenda construction. However, the effects of reward expectations and reward outcomes on memory performance, study time allocation, and learning judgments are moderated by learning conditions.

2.2.5. Trade-off Theory

Studies supporting the Region of Proximal Learning theory were generally conducted under equal value conditions and did not examine the effect of value [23-25]. Conversely, studies supporting value-based item selection generally did not simultaneously examine the effect of difficulty [26, 27].

2.2.6. Interaction between Effort and Metacognitive Monitoring

Research by Baars and colleagues shows that the effort invested in learning or acquiring information (such as time and energy) and metacognitive monitoring judgments are bidirectionally related. The direction of this association may depend on how learners allocate their effort. This study was the first to use meta-analytic methods to investigate the relationship between effort and monitoring. Results showed a moderate negative correlation, indicating that effort is used as a cue for monitoring. Interestingly, the type of monitoring judgment (such as concurrent confidence ratings versus expected judgment errors), task type, and goal-driven manipulations (such as incentives or time pressure) moderated this relationship. This has important implications for future research on using effort as a cue in self-regulated learning [28].

3. Literature Review

3.1. Main Focus of the Literature on Study Time Allocation

The interaction between monitoring and control processes during learning guides how people regulate their study time across items and constitutes the main focus of the literature on study time allocation [7]. Specifically, these studies examine study time allocation under varying item difficulty levels, motivational manipulations, or experimental constraints such as limited time [29].

In addition, recent research trends, based on an analysis of the past five years of publications in the Web of Science database using keywords such as study time allocation, metacognitive control, and self-regulated learning, show that the field is mainly concentrated in educational psychology and multidisciplinary areas of psychology (see Figure 1).

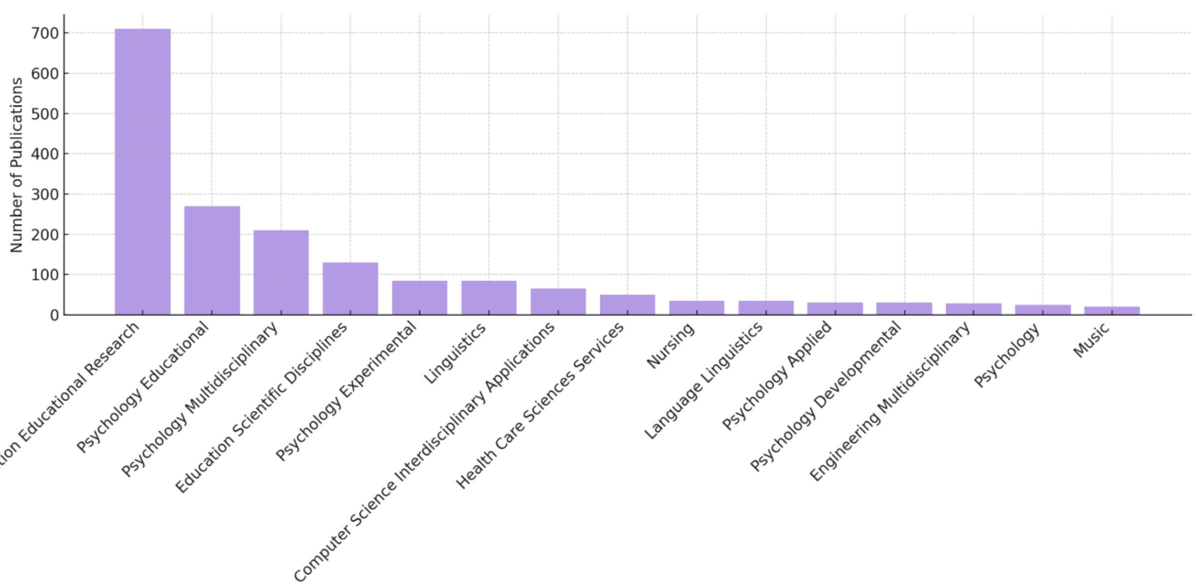

Figure 1.
Distribution of Study Time Allocation, Metacognitive Control, and Self-Regulated Learning Publications Across Disciplines (Last 5 Years, Web of Science)

3.2. Factors Influencing Study Time Allocation

3.2.1. Time Pressure

Most of the time, we find ourselves under tight time constraints when learning new information. This is true not only in our professional lives but is especially so for children and adolescents in educational settings. Such time pressure may affect our metacognitive guidance of decisions, which involves monitoring and controlling our own cognitive processes [30, 31]. In learning contexts, people may monitor their progress and, based on this self-evaluation, decide whether to continue investing time and effort in learning. Equally important is the decision to stop learning [32].

Research by Thiede and Dunlosky [15] also demonstrated that people adopt different study time allocation strategies under varying time pressures. Under greater time pressure, people tend to choose easier items to study [15].

It is worth noting that high time pressure does not necessarily indicate a low goal. Other factors must also be considered and controlled for, as these are two distinct indicators.

3.2.2. Accuracy of Metacognitive Monitoring and Effectiveness of Learning Strategies

Metacognitive monitoring and control must be accurate and efficient to help self-directed learners improve their performance. Research has found that when total study time is held constant, learners who control their study time allocation perform significantly better than those who do not (Experiments 1 and 2). Only learners who adopted a discrepancy reduction strategy, allocating more study time to more difficult items, showed the benefits of self-paced study time allocation. Study time allocation can enhance memory performance, but only when appropriate allocation strategies are employed [14]. The effectiveness of controlling study time allocation is related to two metacognitive skills studied in the literature. First, learners must be able to use effective learning strategies to address items of varying difficulty. Second, the monitoring of items must be relatively accurate, meaning that participants must be able to distinguish which items are easy and which are difficult for them [14]

3.2.3. Item Difficulty

Studies have shown that judgments of learning and study time allocation are influenced by item difficulty [18, 19]. Experiments by Dufresne and Kobasigawa [33] and Dufresne and Kobasigawa [34], and by Kobasigawa and Dufresne [35] and Kobasigawa and Metcalf-Haggert [36] found that elementary school children in lower and middle grades do not always allocate their study time equally to items of varying difficulty. The greater the differences among items and the easier it is to distinguish difficulty levels, the more strategically children allocate their time, showing a tendency to spend more time on difficult items. This demonstrates that different perceptions of item difficulty significantly affect the allocation of study time.

3.2.4. Motivation

External motivation stems from external incentives, meaning the anticipated benefit of an item. The reward structure of an item, including its value and the probability of being tested, influences the estimation and prediction of its benefit.

3.2.5. Learning Goals

The ultimate goal of learning may emphasize speed or accuracy, which often conflict with each other. In real life, both goals usually coexist, making the trade-off more complex.

Anchoring effect. Different instructions, which imply high or low goals, can give participants an initial anchor point that influences their internal goals and thus affects their metacognitive control and study time allocation. Groups with higher goal instructions show better memory performance.

3.3. Types of Measurement for Metacognition, Self-Regulation, and Self-Regulated Learning

There is considerable variation in the types of measurement methods used in research. Dinsmore, et al. [5] documented six types of measurement in their study. These types are self-report, observation, think-aloud protocols, interviews, accuracy ratings, and diaries. From an examination of these data, self-report is the primary measurement type for all three constructs, accounting for nearly 43 percent. The reliance on self-report is much greater in self-regulation and self-regulated learning [5].

3.4. Noteworthy Recent Innovative Research Findings

3.4.1. Using Visualization to Initiate the Self-Regulation Process

Wise self-regulated learning decisions largely depend on monitoring learning and using this information to control the learning process. However, research has found that these processes may not start automatically [37].

To support learners, Schnaubert and Bodemer [37] used prompts and visualization techniques, asking learners to assign confidence levels to learning tasks during restudy and visualize them. They tested the effects on metacognitive and cognitive measures in an experimental study (N = 95). The results showed that prompts for monitoring increased study effort, and visualizing monitoring results during learning focused this effort on uncertain answers. Due to low monitoring accuracy, the self-regulation process did not yield cognitive learning benefits. Although the results support the idea of using visualization techniques to implicitly guide self-regulated learning, more work is needed to improve monitoring accuracy. Additionally, the study indicates that researchers should be aware of the impact that assessing confidence judgments has on subsequent learning behavior. Low monitoring accuracy hinders the transfer to cognitive learning outcomes [37].

3.4.2. Integration of Self-Regulated Learning with Online Learning Models

In the post-pandemic era, as online learning becomes increasingly common, self-regulated learning has become even more important. Many researchers have combined study time allocation research with new models such as online learning.

Research has shown that in online learning, self-regulation mediated by attentional control affects learning procrastination [38]. There have also been many recent findings regarding MOOCs. The ability to engage in self-regulated learning processes contributes to achieving personal goals in MOOCs, with goal setting and strategic planning being seen as strong predictors of goal achievement [39]. Interviews with MOOC students revealed that learners with high levels of self-regulated learning tend to link their online educational experiences with their personal needs, such as career development Littlejohn, et al. [40]. Littlejohn, et al. [40] found that students with high levels of self-regulated learning use more flexible approaches to organize their learning processes. For example, highly self-disciplined students spend more time watching video lectures and submitting weekly quizzes and are more likely to revisit course materials [39].

4. Future Research Directions

4.1. Integration with Economics and Decision-Making

In study time allocation and self-regulated learning, learners tend to aim for maximum benefit with minimum effort. At the same time, they need to weigh the time cost invested against the value brought by the learning items. This is closely aligned with the rational choice assumption in economics. In addition, study time allocation is essentially a series of decisions, making it applicable within the framework of decision-making theories as well. Combining study time allocation research with established theories and assumptions from these two fields could yield valuable insights.

4.2. Does Memory Performance Actually Improve

As previously mentioned, one of the goals of study time allocation is the objective improvement of memory performance.

Most current studies have examined study time allocation under varying item difficulty levels, motivational manipulations, or experimental constraints such as limited time. However, it remains unclear whether people actually benefit from adjusting their study time allocation. In other words, these studies have rarely tested whether individuals' self-regulated study behavior truly improves subsequent memory performance [7].

Researchers have studied in detail how people allocate their study time and have developed several relatively robust theoretical mechanisms. However, these do not address whether study time allocation is truly effective in real-world contexts. While we know what people are doing, it is still unclear what people should be doing.

For example, Metcalfe and Kornell [17] in their paper on the Region of Proximal Learning model pointed out that it cannot be assumed that the model's metacognitive control achieves optimal effectiveness. Even if an individual's behavior completely aligns with the model, caution is needed before concluding that they are demonstrating good metacognitive control. The main issue not addressed by current models is the question of effectiveness. The model describes what people do rather than what they should do. We still do not know whether their actions improve their learning ability or whether they are optimal in any respect. Although people's strategies show nuance and experimental results align with the model's predictions, we cannot fully agree that the model represents good metacognitive control until the unresolved question of effectiveness is answered [17].

4.3. Influence of Learning Strategies

The choice of learning strategies, meaning how to learn, can influence how people allocate their study time [7]. Research has shown that self-paced learning can improve memory performance, but only when appropriate allocation strategies are used [14]. This demonstrates that learning strategies are a crucial factor in study time allocation research. Future studies may further clarify the conceptual boundaries and relationships among self-regulated learning, learning strategies, and study time allocation, and investigate how learning strategies exert their influence in this context.

4.4. Interdisciplinary Integration and Cross-Field Convergence

Researchers in the three main domains of self-regulation research—learning and development, health, and work—believe that the self-regulation processes they study are vital for the development and maintenance of outcome variables relevant to their respective contexts. However, the complexity and diversity of self-regulation within their own fields often hinder them from examining self-regulation from a broader perspective [11]. Furthermore, metacognitive strategies have extensive transferability. This suggests that interdisciplinary integration is an important trend for the fields of study time allocation and metacognitive control.

5. Conclusion

The present review has synthesized the conceptual origins, theoretical developments, and current evidence surrounding study time allocation as an essential part of metacognition and self-regulated learning. Drawing on decades of research, it is clear that study time allocation is not simply about how long one studies, but reflects the dynamic interaction between metacognitive monitoring, strategic control, and individual learning goals.

This body of work shows that learners' ability to monitor their understanding and adjust effort accordingly is foundational to effective study time allocation. Classic and contemporary models, including the discrepancy reduction model and the region of proximal learning framework, have provided valuable explanations for how learners choose what to study and for how long. Yet, despite these theoretical advances, findings still show that learners' actual allocation decisions are not always optimal, especially under conditions such as high time pressure or when monitoring is inaccurate.

A critical question that remains is whether and how study time allocation improves learning outcomes in practice. While laboratory studies have illustrated consistent patterns of choice and persistence, evidence on whether these behaviors translate into better memory performance outside controlled settings is still inconclusive. This suggests that understanding what learners do is only one side of the question; clarifying what they should do, and under what conditions, is equally important.

Another point highlighted in this review is that study time allocation does not occur in isolation but is influenced by task difficulty, reward structures, learning goals, and strategy use. How these factors interact is not yet fully understood. In particular, the role of strategic flexibility—how learners adapt allocation to match changing demands—deserves further empirical attention.

Finally, this topic does not stand alone within educational psychology. The findings have relevance for broader issues such as training metacognitive skills, designing learning environments that foster self-regulation, and even aligning cognitive models with insights from decision-making research. Future studies should continue to test how theoretical principles hold up in real educational contexts, including digital and self-paced learning, where learners must independently monitor and control their effort.

In sum, study time allocation research has made important contributions to our understanding of how learners manage their cognitive resources. Progress will depend on bridging gaps between what we know about monitoring, control, and actual learning gains, and on refining strategies that support learners in making time allocation decisions that are both efficient and genuinely effective.

Transparency:

The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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