

# COGNITIVE LOAD MANAGEMENT AS INFLUENCED BY PERCEIVED TASK COMPLEXITY AMONG UNIVERSITY STUDENTS IN JIANGXI PROVINCE, CHINA

## *GESTÃO DA CARGA COGNITIVA INFLUENCIADA PELA COMPLEXIDADE PERCEBIDA DAS TAREFAS ENTRE ESTUDANTES UNIVERSITÁRIOS NA PROVÍNCIA DE JIANGXI, CHINA*

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### **Abstract**

This study aims to investigate the impact of perceived task complexity on cognitive load among university students in Jiangxi Province, China, and the mediating role of metacognitive strategies therein. Employing a questionnaire survey methodology, the research targeted university students in Jiangxi Province. Data collection utilised the Perceived Task Complexity Scale, Metacognitive Strategies Scale, and Cognitive Load Scale, resulting in 735 valid responses. Research findings indicate that significant differences exist between male and female university students in terms of perceived task complexity, metacognitive strategies, and cognitive load. Significant differences exist among university students of different years in their perception of task complexity, whilst no significant differences are found in cognitive load or metacognitive strategies. Perceived task complexity exerts a significant positive influence on cognitive load; perceived task complexity exerts a significant negative influence on metacognitive strategies; metacognitive strategies exert a significant negative influence on cognitive load; metacognitive strategies partially mediate the relationship between perceived task complexity and cognitive load. The research findings provide richer empirical evidence for elucidating the cognitive regulation mechanisms among university students, and offer a reference basis for optimising teaching

### **Resumo**

*Este estudo tem como objetivo investigar o impacto da complexidade percebida da tarefa sobre a carga cognitiva entre estudantes universitários da província de Jiangxi, na China, bem como o papel mediador das estratégias metacognitivas nesse contexto. Utilizando uma metodologia de pesquisa por questionário, o estudo teve como alvo estudantes universitários da província de Jiangxi. A coleta de dados contou com a Escala de Complexidade Percebida da Tarefa, a Escala de Estratégias Metacognitivas e a Escala de Carga Cognitiva, resultando em 735 respostas válidas. Os resultados da pesquisa indicam que existem diferenças significativas entre estudantes universitários do sexo masculino e feminino em termos de complexidade percebida da tarefa, estratégias metacognitivas e carga cognitiva. Existem diferenças significativas entre estudantes universitários de diferentes anos em sua percepção da complexidade da tarefa, enquanto não foram encontradas diferenças significativas na carga cognitiva ou nas estratégias metacognitivas. A complexidade percebida da tarefa exerce uma influência positiva significativa sobre a carga cognitiva; a complexidade percebida da tarefa exerce uma influência negativa significativa sobre as estratégias metacognitivas; as estratégias metacognitivas exercem uma influência negativa significativa sobre a carga cognitiva;*



task design and learning support strategies within higher education institutions.

**Keywords:** Perceiving Task Complexity. Cognitive Load. Metacognitive Strategies. Self-Regulated Learning Theory. University Students.

*as estratégias metacognitivas mediam parcialmente a relação entre a complexidade percebida da tarefa e a carga cognitiva. Os resultados da pesquisa fornecem evidências empíricas mais ricas para elucidar os mecanismos de regulação cognitiva entre estudantes universitários e oferecem uma base de referência para otimizar o desenho de tarefas de ensino e as estratégias de apoio à aprendizagem em instituições de ensino superior.*

**Palavras-chave:** *Percepção da Complexidade da Tarefa. Carga Cognitiva. Estratégias Metacognitivas. Teoria da Aprendizagem Autorregulada. Estudantes Universitários.*

## 1 INTRODUCTION

In recent years, China's comprehensive higher education system has seen continuous development, with teaching methodologies and learning environments progressively evolving towards digitalisation and greater diversity. Such advancements place heightened demands upon university students' learning abilities and capacity for self-regulation. Against the backdrop of an evolving curriculum and increasingly complex learning tasks, university students are required to integrate more diverse and complex information resources within limited timeframes, leading to a persistently rising cognitive load throughout the learning process (Sweller, 2020). Cognitive overload diminishes learning effectiveness and may exert adverse effects on learners' engagement levels and psychological adaptation, potentially compromising long-term learning performance and persistence. Given the complex conditions of contemporary learning environments, achieving optimal regulation of cognitive load through instructional design and learning strategy optimisation has progressively emerged as a significant focus within higher education research and teaching practice.

Perceived task complexity is widely regarded as a crucial prior factor influencing the formation of cognitive load within specific learning task contexts. Learning requires individuals to manage multiple information sources, execute steps across different procedures, and perform coordinated multitasking. Since cognitive resources are limited, excessive demands can significantly increase cognitive load during the learning process

(Skulmowski & Xu, 2022). Further research indicates the deepening complexity of university course content structures and increasingly intricate teaching task organization. Facing learning environments characterized by high information intensity and multiple task demands, students are more prone to cognitive resource depletion. Such depletion heightens learning burdens and impairs learning efficiency (Hofer *et al.*, 2021). The impact of task complexity on learning outcomes, therefore, does not exhibit a unidirectional relationship. The varying abilities of different learners to employ strategies may lead to differing degrees of cognitive load responses in complex learning situations, indicating that the relationship between task complexity and cognitive load likely depends on learners' internal regulatory processes.

Self-regulated learning theory proposes that learners can effectively manage the learning process through metacognitive strategies such as planning, monitoring, and adjustment. Consequently, cognitive resources are optimized and learning outcomes enhanced (Pintrich, 2000). Prior empirical research shows that the strategic use of metacognitive strategies in complex learning environments assists in reducing unnecessary cognitive processing. Reducing redundant cognitive load promotes learners' ability to maintain stable learning efficiency across task performance (Mizumoto, 2023). At the same time, variations in the use of metacognitive strategies may influence cognitive resource allocation when learners confront more complex learning tasks, thereby altering the pathways through cognitive load formation. Therefore, in learning contexts with continuously increasing task complexity, metacognitive strategies may play a significant mediating role between task complexity and cognitive load.

However, current research has primarily focused on experimental controlled environments or single discipline fields. Systematic investigations into how undergraduate students at comprehensive universities regulate the relationship between task complexity and cognitive load through metacognitive strategies in authentic learning environments remain relatively scarce. Particularly within the context of regional higher education in China, there is considerable scope for further accumulation of empirical data. Consequently, this study focuses on undergraduate students at comprehensive universities in Jiangxi Province, China. A systematic study examines the mechanisms by which the complexity of perceptual tasks influences cognitive load, and further tests the mediating role of metacognitive strategies in this relationship. To provide further empirical evidence

for elucidating the cognitive regulation mechanisms of university students in complex learning environments, and to offer a reference basis for optimizing instructional task design and learning support strategies in higher education institutions.

## **2 LITERATURE REVIEW AND HYPOTHESES**

### **2.1 Theoretical foundations**

Self-Regulated Learning (SRL) theory provides a systematic analytical framework for explaining how learners actively regulate their cognition and behavior in complex learning situations. Zimmerman (1989) noted that the learning process typically involves cyclical stages such as goal setting, strategy selection, learning monitoring, and outcome reflection. Pintrich and Zeidner (2000) further emphasized that learners, during the learning process, are required not only to process external task information but also to simultaneously regulate motivational states, emotional responses, and metacognitive abilities, thereby establishing a sustained learning regulation mechanism. The formation of learning effectiveness is not solely influenced by instructional content, but rather determined by the interaction among task characteristics, individual abilities, and the learning environment. Learners' ability to effectively manage cognitive resources and employ strategies according to task demands significantly impacts the efficiency and stability of the learning process (Ku & Ho, 2010).

In the self-regulated learning theoretical framework, task complexity is regarded as a crucial situational variable influencing the learning process. The level of task complexity typically manifests as a composite reflection of the information processing demands, procedural complexity, and uncertainty in solution pathways throughout task performance (Byström & Järvelin, 1995). Learning tasks involving the integrated processing of multiple pieces of information and complex judgment require learners to invest more cognitive resources in processing, thereby increasing cognitive load levels (Sweller, 2010). Cognitive load is not static; metacognitive strategies serve a regulatory function by reducing inefficient cognitive processing and optimizing information processing routes (Wilson & Conyers, 2016). Consequently, the impact of task complexity on learning outcomes requires analysis within the context of strategy

application. Differences in strategic competence may lead to significant variations in cognitive load performance under complex task conditions.

SRL theory posits the individual actively copes with high cognitive load. Through metacognitive regulation, redundant cognitive effort can be reduced, allowing for superior learning efficiency at a given task level (Zimmerman, 1989). Cognitive load for highly complex tasks is not a fixed value. Learners can regulate perceived pressure through strategic choices and resource management, achieving dynamic control over overload risks within a self-regulated learning framework (Evans *et al.*, 2024).

Metacognitive strategies serve as a critical mechanism in self-regulation processes. Primarily manifested through prior planning, monitoring and evaluation during learning, and reflective adjustments after learning concludes (Zimmerman, 2002). Empirical research indicates that the effective use of planning, monitoring, and regulation strategies enables early detection of learning gaps and adjustment of learning paths. Thus, reduced redundant cognitive processing helps mitigate the negative impact of heavy cognitive load on learning performance (Bao & Pham, 2021). In complex learning task conditions, metacognitive strategies may play a mediating role between perceived task complexity and cognitive load by optimizing the distribution of cognitive resources. As a result, learners are able to maintain relatively stable learning efficiency even when facing highly complex tasks.

Self-regulated learning theory also highlights the significant influence of learning environments and resource conditions on learning regulation behaviors. Learner resources usually include time and learning environment management, peer support, and teacher guidance as internal conditions. The process also involves mental factors such as emotional regulation and maintaining learning motivation (Bandura, 1986). In learning environments with rich resources where learners possess the ability to make effective use of such resources, the role of strategy regulation becomes more readily realized. The result may be a reduction in the cognitive overload associated with more difficult tasks. Conversely, in environments of limited available resources or limited resource management capabilities, even learners with a sense of strategy may struggle to apply effective regulation due to environmental limitations. Subsequently, cognitive overload may occur during complex tasks (Chu *et al.*, 2023; Yu *et al.*, 2024).

All in all, self-regulated learning theory effectively provides a systematic account of the dynamic interplay between cognitive processing, strategy deployment, and resource management among learners across tasks of varying degrees of difficulty. Achieve proactive management of learning behaviors through planning, monitoring, and regulation processes (Winne & Hadwin, 1998). Provide a unifying framework for analyzing the relationship between task demands, cognitive load, and strategy use (Pliner & Johnson, 2004). In this research model, metacognitive strategies serve as a crucial mediating variable explaining the influence of perceived task complexity on cognitive load.

## 2.2 Cognitive load

Hibbeler (2011) defines load as the total amount of force exerted on a physical device or physiological structure per unit of time. O'Donnell and Eggemeier (1986) defined cognitive load as the degree to which an individual's information processing capacity is utilized while performing a specific task, indicating that cognitive load measurement serves as an assessment of certain aspects of information processing capacity. Hart (1988) posits that cognitive load reflects the proportional relationship between an individual's available mental processing resources and the demands of a task. This study adopts the perspective of Kalyuga *et al.* (1998), which defines cognitive load as the total cognitive resources expended by an individual during learning or task performance to process information.

Sweller's (1994) research achieved the transfer of findings on cognitive load from human engineering to the field of cognitive psychology. Cognitive load research has undergone deep integration with modern cognitive theories such as working memory theory and cognitive resources theory (Fagerholm *et al.*, 2022). Mental load and cognitive load share a high similarity in essence, both focusing on the relationship between the brain's information processing capacity and the consumption of psychological resources (Rauffet *et al.*, 2024). Cognitive load, as a psychological state, prompts individuals to transition from passive information recipients to active resource allocators, continually adjusting cognitive strategies in task execution, information construction, and mental energy distribution (Liu, 2020). Cognitive load is not a static entity but rather the result

of dynamic construction, with its formation mechanism involving the interactive integration of three dimensions: task relevance, working memory limitations, and mental energy support (Wingfield, 2016). Previous research findings have established a foundation for this study to further understand how cognitive load influences teaching innovation behavior through the allocation of cognitive resources, while also expanding the analysis of the mechanism linking cognitive load to academic performance.

### 2.3 Perceiving task complexity

Wickens *et al.* (1987) were the first to analyze individual performance from the perspective of multiple resource allocation, arguing that perceived task complexity directly determines the degree of psychological resource consumption. The multiple resource theory laid the theoretical foundation for subsequent research on perceived task complexity. Liu and Li (2012) categorized the perceived complexity of tasks into two core dimensions: the objective complexity of the task and the interaction with an individual's subjective perception. The difficulty of a task depends not only on objective factors such as information presentation methods and time constraints, but also on subjective characteristics like learners' previous knowledge and motivation levels. External environments and internal characteristics collectively form a dynamic cognitive evaluation system, driving the dual evolution of perceptual assessment and task performance. Sweller (1994) pointed out that unreasonable task design can lead to cognitive overload, emphasizing that the core objective of task difficulty perception is to achieve the optimal allocation of cognitive resources.

Torrens-Burton *et al.* (2017) provide an operational definition of task complexity perception, emphasizing the decisive role of individual subjective experience within the objective task structure. Robinson (2001) indicates that teachers create specific cognitive challenge environments by setting time constraints, collaborative requirements, and feedback mechanisms, thereby embodying the dynamic characteristics of task design. Additionally, through resource allocation within multimodal learning and collaborative settings, the complexity of task cognition is highlighted. This study adopts Almaatouq *et al.*'s (2021) definition of perceived task complexity, which posits that perceived task complexity manifests not only as the overall cognitive resources required for university

students to complete learning tasks. It also emphasizes the overall difficulty level when facing multiple challenges, specifically the total subjective experience in the process of matching task demands with individual capabilities.

## **2.4 Metacognitive strategies**

Flavell (1979) first introduced the concept of metacognition, referring to an individual's awareness and monitoring of own cognitive processes. Metacognitive strategies influence learners' conscious awareness of their thinking processes and determine their ability to dynamically adjust learning approaches when facing academic challenges. Brown (1978) define metacognitive strategies as an individual's ability to plan, monitor, and evaluate cognitive processes. Metacognitive strategies originate from learners' judgments regarding whether the effectiveness of strategy use is sufficient to support task objectives, when confronted with complex problems, whether learners believe they can achieve predetermined plans and learning goals through strategy adjustments. Pintrich and Zeidner (2000) noted that metacognitive strategies also encompass individuals' awareness of their own comprehension difficulties and their capacity for reflecting on strategy effectiveness. Furthermore, self-awareness is emphasized as a dual requirement across two dimensions: perceiving learning needs and evaluating performance outcomes. Learners not only assess whether specific strategies can be implemented during the learning process, but also evaluate whether the strategies employed possess practical value for solving problems. Zimmerman (1989) approaches the concept from the perspective of self-regulated learning, positing that metacognitive strategies manifest in learners' flexible monitoring and overall control of their confidence in performance based on specific task objectives. This study adopts the concept of metacognitive strategies proposed by O'Malley and Chamot (1990) which refers to a category of executive strategies through which learners integrate and optimize their cognitive processes by employing higher-order self-regulatory behaviors such as planning, monitoring, and evaluation.

## 2.5 Research hypothesis

To further explore the relationship among task complexity perception, cognitive load, and metacognitive strategies among university students in Jiangxi Province, China, this study will examine how these variables differ across gender and grade levels.

Regarding gender, Yu (2019) used a hybrid research design to explore the impact of gender on cognitive load during mobile English learning. Using the NASA-TLX scale to measure cognitive load, the findings revealed that male students exhibited significantly lower cognitive load than female students, indicating a significant gender difference in cognitive load. Zhou (2014) investigated gender differences in online search behavior across varying levels of task complexity. The results indicated that men exhibited significantly more search activity when performing tasks of moderate perceived complexity, while women engaged in less activity under the same conditions. Carr and Jessup (1997) investigated gender differences in mathematical strategy use and their metacognitive influences among 58 first-grade students in a Georgia elementary school. The findings revealed that girls tended to employ explicit strategies, while boys favored implicit strategies. Gender differences were significantly correlated with metacognitive strategies, H1: University students in Jiangxi Province, China, exhibit significant differences in cognitive load, perceived task complexity, and metacognitive strategies based on gender. H1a: University students in Jiangxi Province, China, exhibit significant differences in cognitive load based on gender. H1b: University students in Jiangxi Province, China, exhibit significant differences in perceived task complexity based on gender. H1c: University students in Jiangxi Province, China, exhibit significant differences in metacognitive strategies based on gender.

Regarding grade level, Chang and Yang (2010) examined cognitive load performance among high school students in different grades during a web-based global warming course. The study involved 105 eleventh-grade students divided into high cognitive load (HCL), medium cognitive load (MCL), and low cognitive load (LCL) groups based on the standard deviation of total cognitive load scores. Results indicated that the LCL group exhibited significantly lower cognitive load than both the MCL and HCL groups. Lynch *et al.* (2013) investigated the impact of perceived task complexity on student performance across different grade levels. The simplest task group demonstrated

the most significant improvement, while the most difficult task group showed the least progress. The study revealed that increased perceived task complexity diminishes student motivation and task commitment, thereby adversely affecting learning outcomes. Akyol *et al.* (2010) examined differences in students' use of metacognitive strategies during science learning and found that students scored significantly higher on metacognitive self-regulation strategies than on other strategies. Therefore, based on the aforementioned perspectives, this study proposes the following research hypothesis: H2: University students in Jiangxi Province, China, across different grade levels exhibit significant differences in cognitive load, perceived task complexity, and metacognitive strategies. H2a: University students in Jiangxi Province, China, exhibit significant differences in cognitive load across different academic years. H2b: University students in Jiangxi Province, China, exhibit significant differences in perceived task complexity across different academic years. H2c: University students in Jiangxi Province, China, exhibit significant differences in metacognitive strategies across different academic years.

Regarding the impact of perceived task complexity on cognitive load. Kalyuga *et al.* (1998) found that perceived task complexity directly influences learners' cognitive load. High perceived task complexity significantly increases intrinsic cognitive load, causing learners to expend more cognitive resources during information processing and thereby reducing learning effectiveness. Awwad (2019) noted in their research that increased perceived task complexity significantly elevates learners' cognitive load, leading to tasks being perceived as more difficult. Based on this perspective, this study proposes the following research hypothesis: H3: Perceived task complexity significantly positively influences cognitive load among university students in Jiangxi Province, China.

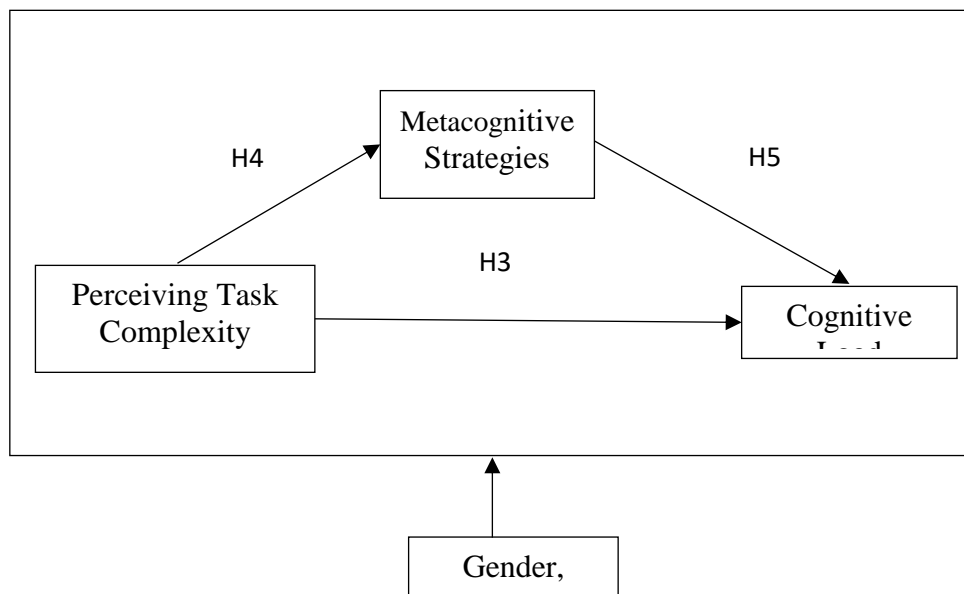
Regarding the impact of perceived task complexity on metacognitive strategies, Autin and Croizet (2012) found that perceived task complexity significantly influences the use of metacognitive strategies by affecting individuals' self-evaluation and mental load. In high complexity task situations, students exhibit reduced application of metacognitive strategies, including planning, monitoring, and evaluation. Zeitlhofer *et al.* (2024) found that as learners' perceived task difficulty increases, metacognitive strategy use significantly reduces. Students with lower abilities, in turn, face greater difficulty employing planning, monitoring, and evaluation strategies effectively in complex task

settings, leading to resource spreading and lower efficiency. Based on these findings, this study proposes the following research hypothesis: H4. Perceived task complexity has a significant negative impact on metacognitive strategy use among university students in Jiangxi Province, China.

Regarding the mediating effect of metacognitive strategies on perceived task complexity and cognitive load, DeStefano and LeFevre (2007) conducted research involving both university undergraduates and readers with lower educational backgrounds. The experimental setting included a comparative analysis of linear text and hypertext reading tasks. The findings revealed that perceived task complexity exerts an indirect influence on cognitive load by affecting the use of metacognitive strategies. Zhang *et al.* (2021) investigated the relationship between perceived task complexity and the use of metacognitive strategies, focusing on how metacognitive strategies mediate between perceived task complexity and cognitive load. The study revealed that perceived task complexity indirectly influences cognitive load by affecting learners' use of metacognitive strategies. Based on the above perspectives, this study proposes the following research hypothesis: H5: Metacognitive strategies employed by university students in Jiangxi Province, China, mediate the relationship between perceived task complexity and cognitive load.

### **3 RESEARCH DESIGN**

This study primarily investigates the impact of perceived task complexity on cognitive load among university students in Jiangxi Province, China, as well as the mediating role of metacognitive strategies between the two. As shown in the research model diagram (Figure 1), task complexity serves as the predictor variable, cognitive load as the target variable, and metacognitive strategies as the mediator variable. Gender and grade level are treated as background variables.

**Figure 1***Research Framework Diagram.*

### 3.1 Research subjects

This study selected university students in Jiangxi Province, China as its research subjects. In recent years, the advancement of comprehensive higher education reform and the accelerated evolution of digital learning environments have led to increasingly diverse and demanding learning needs and task requirements among university students (Petkovics, 2018). In comprehensive universities, students are required not only to complete theoretical and practical tasks across various disciplinary fields but also to master interdisciplinary thinking and innovative skills to excel in diverse professional environments and fulfill multiple roles in the future (Visscher-Voerman *et al.*, 2025). Following Wu (2007) recommendation that the sample size should be at least ten times the number of items in the questionnaire, this study collected a total of 800 survey responses to ensure data breadth and representativeness. During data selection and quality control, to ensure data reliability and validity, questionnaires where respondents selected the same option across multiple consecutive questions, as well as those completed in an unreasonably short time, were flagged as invalid. A total of 65 invalid questionnaires were excluded, resulting in 735 valid questionnaires meeting the study requirements. The questionnaire validity rate was 91.875%.

## 3.2 Data collection methods

Questionnaires are an effective method for collecting large-scale data by distributing surveys to multiple respondents simultaneously, thereby gathering extensive information. The efficiency of survey methods lies in completing data collection within a relatively short timeframe, notably through online surveys. By offering a flexible and easy way for responses, online surveys make it possible for participants to share data based on their own timing and location (Lobe *et al.*, 2022). The cost of the questionnaire survey is low, and the online method can reduce the cost of printing and mailing. The data collection of the quantitative part adopts the convenient sampling method, which is less expensive and does not require additional time, resources and funds to identify and contact respondents, so it has become an economic option for research projects with limited budgets (Zicka & Keith, 2023).

## 3.3 Research tools

This study used the Perceived Task Complexity Scale, the Cognitive Load Scale, and the Metacognitive Strategies Scale. Specific content of the scales is as follows:

### 3.3.1 Cognitive load scale

In this study, the cognitive load scale developed by Zhang *et al.* (2023) was employed. Consisting of three dimensions: intrinsic, extrinsic, and related cognitive load, each dimension includes six items. The scale uses a 5-point Likert scale, with 1–5 representing strongly disagree, tend to disagree, neutral, tend to agree, and strongly agree, respectively. High scores reflect higher cognitive load among test takers. The overall Cronbach's Alpha was .853, with subscale Cronbach's Alpha coefficients of .826, .837, and .872, respectively. All subscales met scholarly reliability standards. Three principal components with loading values exceeding 1 accounted for 62.081% of total variance, exceeding the 60% threshold and indicating good validity.

### 3.3.2 *Perceived task complexity scale*

In this study, the task complexity scale with four items proposed by Maynard and Hakel (1997) was adopted. The scale is unitary in dimension. Using a 5-point Likert scale, 1-5 represent strongly disagree, tend to disagree, neutral, tend to agree, and strongly agree, respectively. High scores indicate higher perceived task complexity among test takers. The overall Cronbach's Alpha for the scale was .893. The factor loadings for the four items were .673, .818, .773, and .875, respectively, showing good internal consistency and construct validity.

### 3.3.3 *Metacognitive strategies scale*

In this study, the University Student Metacognitive Strategy Scale devised by Zhang (2013) was used to measure subjects' levels of metacognitive strategy use. The scale includes 24 items across three dimensions: planning strategies, monitoring strategies, and regulation strategies. The scale uses a 5-point Likert scale, with 1-5 representing strongly disagree, somewhat disagree, neutral, somewhat agree, and strongly agree, respectively. High scores reflect stronger metacognitive strategy use. Overall Cronbach's Alpha was .927, with subscale coefficients of .845, .712, and .863, meeting academic reliability standards. High and significant correlation coefficient between each dimension and the total score, and it has good structural validity.

## 4 RESEARCH RESULTS

### 4.1 *Descriptive statistical analysis*

To investigate the current status of background variables, task complexity perception, cognitive load, and metacognitive strategies among college students in Jiangxi Province, China, this study employs descriptive statistical analysis methods. Background variables for university students in Jiangxi Province included gender and grade level in the study sample. Regarding gender distribution, this study included 346 male participants (47.075%) and 389 female participants (52.925%), showing a relatively

balanced gender distribution. By grade, there are 173 freshmen students (23.537%), 218 sophomores students (29.660%), 187 juniors students (25.442%), and 157 seniors students (21.361%). Because some senior students participated in external internships, the number of students on campus was relatively limited, making it difficult for this study to maintain a completely balanced sample distribution.

This study used the mean and standard deviation to conduct descriptive statistical analysis on three research variables among perceptual task complexity, cognitive load, and metacognitive strategies among university students in Jiangxi Province. Each scale used a 5-point scoring method, with a theoretical median of 3. Therefore, a mean above 3 indicates an above average level, while a mean below 3 indicates only an average or below average level.

Regarding cognitive load, the average cognitive load of college students was 3.353, with a standard deviation of 0.717, which is higher than the theoretical median, indicating that college students are generally in a state of moderate to high cognitive load during the learning process. Regarding perceived task complexity, the overall item average was 3.333 with a standard deviation of 0.990, which is higher than the theoretical median. Findings indicate that the subjects generally believed that the learning tasks they faced had a certain degree of complexity and required a relatively large amount of cognitive resources to understand and complete. Regarding metacognitive strategies, the item average score for metacognitive strategies among university students in Jiangxi Province, China, was 2.620, with a standard deviation of 0.742, both lower than the theoretical median. The findings indicate that university students in Jiangxi Province generally use metacognitive strategies less frequently during the learning process.

## **4.2 Difference analysis**

### *4.2.1 Gender differences*

To test whether significant differences in various variables exist between male and female university students in Jiangxi Province, China, the present study employed an independent samples t-test for analysis.

**Table 1***Analysis of gender differences among university students in Jiangxi Province, China.*

Variables	Male (n=346)		Female (n=389)		<i>t</i>	<i>p</i>	Differential Comparison
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
<b>Cognitive Load</b>	3.285	0.639	3.414	0.776	-2.488	.013	F>M
Intrinsic Cognitive Load	3.273	0.890	3.483	0.935	-3.121	.002	F>M
Extrinsic Cognitive Load	3.378	0.920	3.391	0.961	-0.187	.851	-
Relevance Cognitive Load	3.203	0.949	3.369	0.984	-2.329	.020	F>M
<b>Perceived Task Complexity</b>	3.196	1.021	3.456	0.945	-3.565	.000	F>M
<b>Metacognitive Strategies</b>	2.720	0.682	2.531	0.782	3.501	.000	F<M
Planning Strategies	2.763	0.941	2.570	1.003	2.682	.007	F<M
Monitoring Strategies	2.665	0.920	2.468	0.982	2.788	.005	F<M
Regulation Strategies	2.708	0.917	2.530	0.951	2.578	.011	F<M

Significant gender differences in cognitive load were observed among university students in Jiangxi Province, China ( $t = -2.488, p < .05$ ). Male students ( $M = 3.285, SD = 0.639$ ) and female students ( $M = 3.414, SD = 0.776$ ) exhibited marked differences in cognitive load levels. Female respondents reported significantly higher cognitive load levels than male respondents. In terms of perceived task complexity, significant gender differences were observed among university students in Jiangxi Province, China ( $t = -3.565, p < .001$ ). Female students ( $M = 3.456, SD = 0.945$ ) perceived tasks as significantly more complex than male students ( $M = 3.196, SD = 1.021$ ). Regarding metacognitive strategies, significant gender differences were observed ( $t = 3.501, p < .001$ ). Female students ( $M = 2.531, SD = 0.782$ ) exhibited significantly lower metacognitive strategy scores than male students ( $M = 2.720, SD = 0.682$ ).

#### 4.2.2 Grade difference

To examine whether significant differences exist across different variables among university students in Jiangxi Province, China, across different grade levels, this study employed an independent samples ANOVA for analysis.

At the overall cognitive load level, there was no significant difference between freshmen ( $M=3.339, SD=0.727$ ), sophomores ( $M=3.398, SD=0.666$ ), junior students ( $M=3.366, SD=0.689$ ), and senior students ( $M=3.291, SD=0.806$ ) showed no significant differences, with an *F*-value of 0.718 and a *p*-value of .542 ( $p > .05$ ). This indicates that different grade groups exhibit essentially consistent patterns in the total cognitive

resources allocated during the learning process. Significant grade-level differences were observed in overall task complexity perception. Sophomores ( $M=3.456$ ,  $SD=0.967$ ) scored significantly higher overall than freshmen ( $M=3.126$ ,  $SD=0.942$ ) and seniors ( $M=3.406$ ,  $SD=1.040$ ) scored significantly higher than freshmen ( $M=3.126$ ,  $SD=0.942$ ), with an  $F$  value of 4.003 ( $p<.01$ ). This indicates that sophomores and seniors exhibit a stronger subjective psychological perception of the challenge level in academic tasks. Regarding the monitoring strategy dimension of metacognitive strategies, significant differences emerged across grade levels. Sophomores ( $M=2.737$ ,  $SD=1.038$ ) scored significantly higher than juniors ( $M=2.453$ ,  $SD=0.965$ ) and seniors ( $M=2.454$ ,  $SD=0.865$ ), with an  $F$ -value of 3.950 ( $p<.01$ ). This indicates that sophomore students demonstrate markedly stronger self-monitoring and progress management abilities during the learning process compared to upperclassmen.

**Table 2**

*Analysis of grade differences among university students in Jiangxi Province, China.*

Variables	Freshman ( $n=173$ )	Sophomore ( $n=218$ )	Junior ( $n=187$ )	Senior ( $n=157$ )	$F$	$p$	Post-hoc comparison
	$M$ ( $SD$ )	$M$ ( $SD$ )	$M$ ( $SD$ )	$M$ ( $SD$ )			
<b>Cognitive Load</b>	3.339 (0.727)	3.398 (0.666)	3.366 (0.689)	3.291 (0.806)	0.718	.542	-
Intrinsic Cognitive Load	3.417 (0.853)	3.313 (0.933)	3.485 (0.909)	3.325 (0.977)	1.472	.221	-
Extrinsic Cognitive Load	3.268 (0.909)	3.423 (0.842)	3.352 (0.948)	3.120 (0.986)	0.480	.696	-
Relevance Cognitive Load	3.216 (0.942)	3.459 (0.992)	3.260 (0.965)	3.406 (1.040)	3.936	.008	2>3; 2>4
<b>Perceived Task Complexity</b>	3.126 (0.942)	3.456 (0.967)	3.321 (0.992)	3.406 (1.040)	4.003	.008	2>1; 4>1
<b>Metacognitive Strategies</b>	2.660 (0.760)	2.615 (0.748)	2.687 (0.828)	2.502 (0.578)	2.006	.112	-
Planning Strategies	2.679 (0.961)	2.557 (0.996)	2.820 (1.074)	2.596 (0.826)	2.732	.043	3>2; 3>4
Monitoring Strategies	2.552 (0.906)	2.737 (1.038)	2.453 (0.965)	2.454 (0.865)	3.950	.008	2>3; 2>4
Regulation Strategies	2.719 (1.077)	2.597 (0.841)	2.697 (0.949)	2.421 (0.868)	3.468	.016	1>4; 3>4

### 4.3 Correlation analysis

Cognitive load among university students in Jiangxi Province, China, showed a significant positive correlation with perceived task complexity ( $r = .511, p < .001$ ), and a significant negative correlation with metacognitive strategies ( $r = -.681, p < .001$ ). Perceived task complexity showed a significant negative correlation with metacognitive strategies ( $r = -.473, p < .001$ ). In Chinese university students from Jiangxi Province, correlations between cognitive load, perceived task complexity, and metacognitive strategies were all significantly related ( $p < .001$ ), with correlation coefficients range from  $-.681$  to  $.511$ . All values fell below  $.700$ , indicating no issue of multiple correlation among the variables.

**Table 3**

*Variable correlation analysis.*

	Cognitive Load	Perceived Task Complexity	Metacognitive Strategies
Cognitive Load	1		
Perceived Task Complexity	.511***	1	
Metacognitive Strategies	-.681***	-.473***	1

### 4.4 Regression analysis

This study examined the direct effects of perceived task complexity on cognitive load and metacognitive strategies, as well as the mediating role of metacognitive strategies between perceived task complexity and cognitive load. The research employed a regression model with multiple stepwise regressions and tested for mediating effects, controlling for gender and grade level background variables.

**Table 4**

*Intermediate inspection analysis.*

Note 1: \* $p < .05$ , \*\*\* $p < .001$ .

	Model 1 Cognitive Load		Model 2 Metacognitive strategies		Model 3 Cognitive Load		Model 4 Cognitive Load	
	$\beta$	$t$	$\beta$	$t$	$\beta$	$t$	$\beta$	$t$

Female	.022	0.470	-.107*	-2.171	.015	0.370	-.038	-0.995
Sophomore	-.061	-0.958	.053	0.781	-.031	-0.579	-.032	-0.615
Junior	-.047	-0.724	.097	1.410	-.083	-1.522	.007	0.131
Senior	-.150*	-2.181	-.076	-1.045	-.139	-2.408	.192***	-3.454
Perceived task complexity	.374***	15.936	-.348***	-14.050			.180***	8.407
Metacognitive strategies					-.660***	23.425	-.557***	19.642
$R^2$	.267		.235		.437		.521	
Adj. $R^2$	.262		.230		.434		.517	
$F$	53.069***		44.808***		113.391***		131.868***	

Note 2: Group 1 = Freshmen; Group 2 = Sophomores; Group 3 = Juniors; Group 4 = Seniors. Males and freshmen served as the reference group.

Model 1 regression analysis examining the relationship between perceived task complexity and cognitive load. The analysis results show that the adjusted  $R^2$  is .262, indicating that perceived task complexity explains 26.2% of the variance in cognitive load. The standardized regression coefficient  $\beta$  is .374 and reaches statistical significance ( $p < .001$ ), demonstrating that perceived task complexity has a significant positive effect on cognitive load. That is, the more complex the task, the higher the cognitive load perceived by individuals. Therefore, Hypothesis H2 holds: Task complexity perceived by university students in Jiangxi Province, China, significantly and positively influences cognitive load.

Model 2 regresses the effect of perceived task complexity on metacognitive strategies while controlling for background variables. The analysis revealed an adjusted  $R^2$  of .230, indicating that perceived task complexity explains 23.0% of the variance in metacognitive strategies. The standardized regression coefficient  $\beta$  was -.348 and reached statistical significance ( $p < .001$ ), confirming that perceived task complexity exerts a significant negative influence on metacognitive strategies, the more complex the task, the lower the degree to which university students employ metacognitive strategies. Therefore, Hypothesis H3 holds: Perceived task complexity significantly negatively influences metacognitive strategies among university students in Jiangxi Province, China.

Model 3 regresses the effect of metacognitive strategies on cognitive load while controlling for background variables. The results revealed an adjusted  $R^2$  of .434, indicating that metacognitive strategies explained 43.4% of the variance in cognitive load. The standardized regression coefficient  $\beta$  was -.660 and reached statistical significance ( $p < .001$ ). That is, the stronger the ability to employ metacognitive strategies, the lower

the level of cognitive load experienced by university students. Therefore, Hypothesis H4 holds: Metacognitive strategies significantly negatively influence cognitive load among university students in Jiangxi Province, China.

While controlling for background variables, Model 4 simultaneously incorporated perceived task complexity and metacognitive strategies into the regression model to examine the mediating effect of metacognitive strategies between perceived task complexity and cognitive load. The analysis revealed an adjusted  $R^2$  of .517, indicating that perceived task complexity and metacognitive strategies together explained 51.7% of the variance in cognitive load. In this model, the standardized regression coefficient between perceived task complexity and cognitive load was  $\beta = .180$  ( $p < .001$ ), while the standardized regression coefficient between metacognitive strategies and cognitive load was  $\beta = -.557$  ( $p < .001$ ), both coefficients reached statistical significance. Comparing Model 1 with Model 4, the standardized regression coefficient for perceived task complexity decreased from  $\beta = .374$  ( $p < .001$ ) to  $\beta = .180$  ( $p < .001$ ). Effect size was attenuated but remained significant, indicating that metacognitive strategies partially mediated the relationship between perceived task complexity and cognitive load. Therefore, Hypothesis H5 holds: Metacognitive strategies of university students in Jiangxi Province, China, mediate the relationship between perceived task complexity and cognitive load.

## 5 CONCLUSIONS AND SUGGESTIONS

This study conducted a survey among university students in Jiangxi Province, China, investigating the relationship between perceived task complexity, cognitive load, and metacognitive strategies. The research also examined the differential manifestations of gender and year of study as background variables across all three constructs.

Regarding gender, gender differences were found to be significant across all three dimensions of cognitive load : internal cognitive load, external cognitive load, and related cognitive load. Females exhibited notably higher levels of cognitive load than males. In terms of perceiving task complexity, females exhibit significantly higher levels than males, reflecting systematic differences across multiple levels including cognitive

appraisal of learning tasks, emotional response modes, and learning motivation structures. Regarding metacognitive strategies, significant gender differences were found among university students in Jiangxi Province, China. Males across the board showed higher levels, but females generally scored higher than males in risk cognition, emotional arousal, and feeling of uncertainty (Stevens & Hamann, 2012).

Regarding grade level, no substantial differences in overall cognitive load or the intrinsic and extrinsic dimensions were found among university students in Jiangxi Province, China. For the related cognitive load, sophomore students showed a significant advantage. University students in Jiangxi Province, China, show significant gradation differences in perceiving task complexity, particularly pronounced during the sophomore and senior years. University students in Jiangxi Province, China, did not show significant gradation differences in the use of metacognitive strategies overall, but significant differences exist across strategy dimensions, showing a pattern of phased changes in usage. Senior students tend to score lower than students in lower grades, with seniors scoring significantly lower than freshmen and sophomore students. Such patterns may be due to shifts in the nature of tasks and changes in role positioning during the final stage of university studies (Ruihua *et al.*, 2025). Once students enter the graduation phase, greater responsibility falls on them to undertake tasks such as independently completing their thesis, completing internships and practical training, and preparing for employment. The external support channels available to students become relatively limited. Moreover, some students may reduce their proactive efforts to ask for help due to low personal efficacy or time constraints (Nguyen-Thi *et al.*, 2024).

Regarding the relationship between variables, a significant positive influence exists between perceived task complexity and cognitive load. When confronted with learning tasks exhibiting higher complexity in difficulty structure, information density, and processing levels, university students are more likely to experience substantial processing pressure within their cognitive systems. Subsequently, subjective cognitive load levels increase, thereby constraining learning efficiency and the quality of information integration (Skulmowski & Xu, 2022). Perceived task complexity exhibits a significant negative predictive effect on metacognitive strategy performance, meaning that higher levels of perceived task complexity correlate with lower levels of metacognitive strategy. As the level of conceptual abstraction or the complexity of

problem structures in learning contexts continues to increase, learners' ability to self-regulate their learning processes tends to weaken, making it difficult for metacognitive regulation to effectively perform its regulatory function in complex environments (Panadero, 2017). Metacognitive strategies exert a significant negative influence on cognitive load, meaning that higher levels of metacognitive strategy implementation correlate with lower cognitive load levels. As a crucial mechanism supporting learners in sustaining deep processing, metacognitive strategies alleviate cognitive strain through planning and reflection. When learners lack sufficient metacognitive support capabilities, they struggle to maintain effective regulatory states, thereby increasing the burden on working memory systems (Zimmerman, 2002).

Furthermore, metacognitive strategies exert a partial mediating effect between perceived task complexity and cognitive load. Perceived task complexity can directly increase information processing demands during learning, and indirectly exacerbate the experience of cognitive load by weakening learners' metacognitive strategy levels. Task complexity places direct demands on cognitive systems, and metacognitive strategies play a crucial mediating role in regulating cognitive processing. Learners' ability to allocate cognitive resources in the face of complex tasks is influenced by task complexity and metacognitive strategies, together determining the final manifestation of cognitive load levels (Sweller, 1994; De Jong, 2010).

This study proposes a core goal of fostering the sustained development of university students' self-regulated learning skills, systemically refining the allocation of students' cognitive resources and academic performance. Moving beyond sole reliance on student effort, educational pathways should be reshaped as a complex system centered on teaching design and management process optimization. The ultimate goal is to achieve a dynamic, mutually reinforcing relationship between students' cognitive regulation and the evolution of the educational environment. The learning process of university students is marked by intensive cognitive effort, high mental resource demand, and complexity in task environments. A unified approach with overarching policy guidance, management support at the meso level, and targeted teaching reform at the micro level is needed to transcend the single classroom perspective. The practice and policy proposals put forward by the Institute are grounded in learner resources, guided by the goal of optimizing cognitive load levels, and driven by metacognitive strategies. Focusing on optimization

of the curriculum system, management support systems, task environment regulation, and enhancement of strategic skills, all four dimensions of the proposals collectively emphasize a systemic perspective to drive structural transformation in university teaching operations.

First, place curriculum optimization at the core of student development. Advancing modularized course design and ciently balancing difficulty level progression with pacing allows the learning environment to evolve from a mere knowledge delivery vehicle into a stable cognitive regulation support system. Such an approach prevents the irritation accumulation of cognitive load caused by knowledge discontinuity or teaching pace instability (Mayer & Moreno, 2003). Second, in areas of enhanced support for university management. By creating a regularized unified academic support system, optimized digital resource provision, and improved ongoing faculty guidance systems, learning support has evolved from reactive, fragmented interventions to organized safeguards and institutional norms. As a result, students' cognitive abilities and coping strategies regarding task complexity have been optimized at the macro level (Pascarella & Terenzini, 2005; Sweller *et al.*, 2011). Third, at the level of improved metacognitive strategy skills. A systematic cultivation mechanism involving modeling, guidance, practice, and feedback is developed to facilitate the shift from explicit strategies to learning habits and foster collaborative professional reflection structures. Continuously enhancing both students' cognitive regulation beliefs and action ability when facing complex task scenarios, the approach elevates students' problem sensitivity and learning efficacy (Zimmerman, 2002; Veenman *et al.*, 2006). Fourth, in terms of dynamic task environment regulation. Centered on task clarity and information presentation optimization, the approach provides a stable learning environment with clear learning objectives, operational steps, and rubrics for students at varying cognitive levels. Reducing ineffective processing costs stemming from uncertainty, the method offers structural safeguards for enhancing learning quality (Panadero & Jonsson, 2013).

### **CONFLICT OF INTEREST**

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## AUTHOR CONTRIBUTIONS

All authors contributed to the article and approved the submitted version.

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### **Authors' Contribution**

All authors contributed equally to the development of this article.

### **Data availability**

All datasets relevant to this study's findings are fully available within the article.

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