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Research Article

The Effect of Meta-Cognitive Skills Management And Skills Engagement On Cognitive Outcome Of Students During Online Learning In Selected Universities In Beijing, China

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ABSTRACT

The fast development of technology has changed conventional educational systems and offers possibilities and problems for online learning settings. The COVID-19 epidemic has sped up the acceptance of online learning, which calls for a review of approaches to improve student engagement and cognitive outcomes. This article examines the effect of meta-cognitive skills management and skill engagement on cognitive outcomes during online learning in Beijing, China, universities through a cross-sectional survey comprising 400 students. The results show that meta-cognitive skills management and engagement greatly affect cognitive outcomes, with skills engagement acting as a mediator. These findings highlight the need to develop metacognitive abilities and active participation to raise cognitive performance in online learning environments.

Keywords: meta-cognitive skills management, skills engagement, cognitive outcomes

INTRODUCTION

The rapid advancement of technology has transformed traditional classroom environments and presents advantages and challenges for online learning environments. Particularly in response to the COVID-19 epidemic, online learning has recently become a necessary component of higher education (Dhawan, 2020). This development calls for a review of the strategies applied to raise student engagement in virtual environments and academic performance. Among these strategies, active student engagement and the development and control of meta-cognitive skills management largely determine desired cognitive consequences.

Meta-cognitive skills management—which comprises the ability to organize, track, and evaluate one's learning processes—has been connected to academic performance (Küçükaydın, 2024). These skills enable students to grow into self-directed learners who are able to manage the difficulties of online learning effectively. On the other hand, skills engagement explains how much students actively engage in the cognitive and behavioral elements of learning (Wong & Liem, 2022). This comprises chores, including assignments, supporting discussions, and student interaction. Although meta-cognitive skills and abilities engagement are commonly considered vital, empirical studies on their particular effects on cognitive results in online learning environments are rare, especially in the context of Beijing, China's higher education institutions. Since most past studies have focused on traditional classroom contexts(Ozkan Bekiroglu et al., 2022), a vacuum remains in our knowledge of how these components apply to virtual environments.

Teachers and students have significant challenges from the rapid shift to online learning of the COVID-19 epidemic. Students have struggled with self-control, time management, and motivational maintenance without fundamental classroom frameworks (Rahayu et al., 2024). Teachers have struggled to provide engaging and dynamic online content, monitor student development, and provide timely comments (Kelley, 2021).

Moreover, the abrupt shift has exposed variations in student access to technology and digital competency, making online learning more challenging (Núñez-Canal et al., 2022). Higher education in Beijing's distinctive cultural and pedagogical demands placed on students, which can influence their involvement and performance in virtual learning settings, aggravate these challenges (Liu et al., 2022). Therefore, this study has been conducted with the following objectives:

1. To identify the effect of meta-cognitive skills management on skills engagement during online learning in selected universities in Beijing, China
2. To study the effect of meta-cognitive skills management on cognitive outcome during online learning in selected universities in Beijing, China.
3. To study the effect of skills engagement on cognitive outcome during online learning in selected universities in Beijing, China.
4. To analyze the role of skills engagement as a mediator in the relationship between meta-cognitive skills management and cognitive outcome during online learning in selected universities in Beijing, China.

This study also come out with several hypotheses thar are:
H1. Meta-cognitive skills management has a significant effect on skills engagement during online learning in selected universities in Beijing, China
H2. Meta-cognitive skills management has a significant effect on cognitive outcome during online learning in selected universities in Beijing, China.
H3. Skills engagement has significant effect on cognitive outcome during online leaning in selected universities in Beijing, China.
H4. Skills engagement significantly mediates the relationship between meta-cognitive skills management and cognitive outcome during online learning in selected universities in Beijing, China.

The findings of this study will address a knowledge gap on the influence of meta-cognitive skills management and engagement on cognitive outcomes in online learning, therefore augmenting the body of knowledge already in use. This study on acquiring meta-cognitive skills management and motivating active engagement in virtual classrooms can provide great insights to teachers, legislators, and curriculum designers.

Establishing effective teaching strategies that increase student accomplishment and pleasure depends on knowing the factors influencing cognitive results in online learning. This research will benefit Beijing and other universities since it will direct best practices for helping students learn online. The recommendations derived from this study will enable the development of targeted treatments to enhance students' metacognitive skills management and skills engagement, therefore strengthening their academic performance.

LITERATURE REVIEW

Globally and in China, online learning has become very popular in higher education (Tang et al., 2021). Earlier research has brought to light several aspects of online learning in Chinese higher education. Bao (2020) discovered in a similar vein that active student participation and well-structured instructional design are essential components of successful online education (Bao, 2020). Chen et al. (2021) also looked into how online learning affected student performance and satisfaction, finding that essential elements in the success of online education include the interaction between teachers and students and the ability of students to manage their learning (Chen et al., 2020). In their study of the psychological impacts of extended online learning on students, Zhao et al. (2021) found that the difficulties of juggling home and academic obligations and the absence of in-person interaction led to higher levels of stress and anxiety (Zhao et al., 2020).

Intelligent tutoring systems (ITS) are one example of an interactive online educational technology that research indicates can offer a robust platform for metacognitive support, particularly while studying complex disciplines like computer programming. Planning, monitoring, and assessing problem-solving processes are among the effective metacognitive strategies that high achievers employ more often than do low achievers (Rum & Ismail, 2017). Furthermore, recommender systems can improve the metacognitive abilities of online learners by directing and suggesting learning activities, therefore enabling students to keep an eye on and manage their own learning. Nevertheless, such features are currently included in a few e-learning systems (Zhou & Xu, 2013).

Plan, monitor, and evaluate are examples of metacognitive techniques in language learning that can significantly enhance independent learning in college English courses. These techniques should be part of an excellent Internet-based learning model to raise learning results (Teng et al., 2023). Moreover, metacognitive skill development in online learning environments can be successfully supported by a metacognitive tutoring tool designed for use in a learning management system (LMS). In several cognitive areas, these methods have been demonstrated to enhance cognitive control (Carlon et al., 2021). Managing cognitive processing—deep processing and the application of affective and metacognitive techniques—is another need for successful online

learning. These techniques are much influenced by the learners' surroundings and traits (Chen & Pedersen, 2012).

Skills engagement is a multifaceted construct that includes behavioral, emotional, and cognitive dimensions of student involvement in learning (Lin, 2021). Behavioral engagement refers to participation in academic activities, emotional engagement pertains to students' attitudes and interests, and cognitive engagement involves the investment in learning and the willingness to understand complex ideas.

Research has demonstrated that high levels of skills engagement are associated with better learning outcomes. For instance, students actively engaged in online discussions, collaborative projects, and interactive activities tend to exhibit higher levels of understanding and retention of course material (Trinidad et al., 2020). Moreover, engagement in online learning environments has been linked to increased satisfaction and persistence, which are critical for academic success (El-Sayad et al., 2021).

Perceived school support significantly enhances online learning outcomes through the mediation of academic self-efficacy and online learning engagement (Wang et al., 2022). During the COVID-19 pandemic, Chinese EFL learners' engagement, satisfaction, and self-efficacy were critical for sustainable online learning development. Behavioral and emotional engagements were positively linked to student cohesiveness and involvement (Han et al., 2021). A case study on financial accounting courses at an international joint venture university in China found that online review exercises significantly increased student engagement and exam performance (Cheng & Ding, 2021).

Cognitive outcomes refer to the intellectual skills and knowledge students acquire through learning. In online learning environments, cognitive outcomes can be influenced by various factors, including instructional design, interaction with content, and the use of technology (Skulmowski & Xu, 2022). Practical online courses are designed to promote critical thinking, problem-solving, and the application of knowledge in realworld contexts. Several studies have investigated the impact of online learning on cognitive outcomes. For instance, Bernard et al. (2009) conducted a meta-analysis of distance education studies and found that online learning can be as effective as traditional face-to-face instruction in terms of student learning outcomes. The study highlighted the importance of interaction between students and instructors or among peers as a key factor in achieving positive cognitive outcomes (Bernard et al., 2009). Fiock (2020) introduced the Community of Inquiry framework, emphasizing the roles of cognitive presence, social presence, and teaching presence in online learning environments. Cognitive presence, in particular, relates to how learners can construct and confirm meaning through sustained reflection and discourse, which is crucial for achieving deep learning (Fiock, 2020).

The use of technology in online learning also influences cognitive outcomes. For example, Sagagh (2021) examined the impact of adaptive learning technologies on student performance and found that such technologies can personalize learning experiences and improve cognitive outcomes by providing timely feedback and tailored instructional content (El-Sabagh, 2021). Similarly, the effects of technology in education concluded that technology can enhance cognitive outcomes when integrated thoughtfully into the learning process (Bernacki et al., 2020).

Theoretical framework

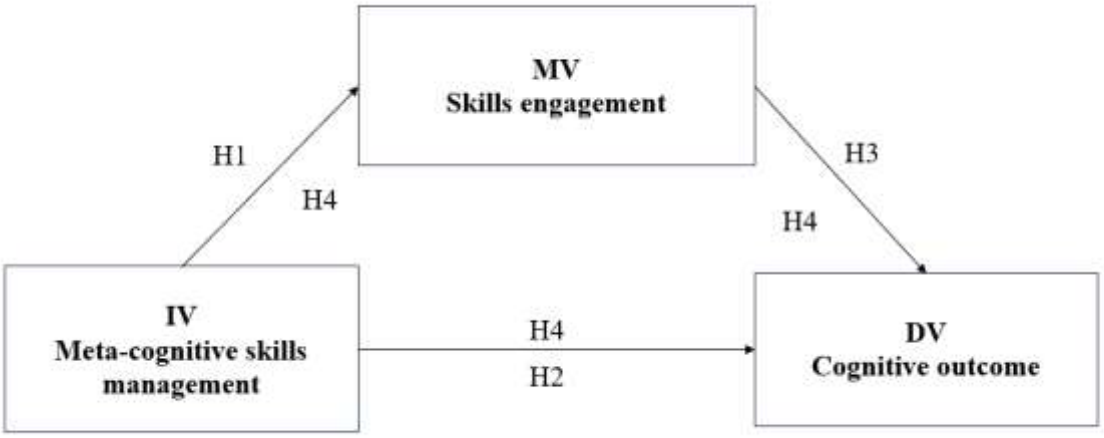
The theoretical framework of this study consists of three main models: Flavell's model of meta-cognition, the Community of Inquiry, and Bloom's taxonomy. Flavell's model of meta-cognition posits that meta-cognition involves two main components: meta-cognitive knowledge, which is the awareness of one's cognitive processes, and meta-cognitive regulation, which is the control over these processes. In the context of this study, meta-cognitive skills management refers to the ability of students to plan, monitor, and evaluate their learning strategies during online learning. This skill is crucial in online environments where learners must manage their study schedules and tasks independently, without the immediate presence of a teacher. The findings that meta-cognitive skills management positively influences both skills engagement and cognitive outcomes underscore the importance of these skills in fostering self-directed learning and improving academic performance (Flavell, 1979).

The Community of Inquiry (CoI) framework outlines three core elements essential for successful online learning: cognitive presence, social presence, and teaching presence. Skills engagement, as discussed in the study, aligns with the concept of cognitive presence. Cognitive presence refers to how learners construct and confirm meaning through sustained reflection and discourse. Skills engagement involves deep interaction with the content, active participation in discussions, and critical thinking. This engagement is essential for achieving meaningful learning experiences and online cognitive outcome. The study's findings that skills engagement mediates the relationship between meta-cognitive skills management and cognitive outcomes highlight the role of cognitive presence in enhancing students' learning experiences and outcomes (Garrison et al., 1999).

Bloom's Taxonomy classifies cognitive outcomes into six hierarchical levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. Cognitive outcomes in online learning refer to the intellectual skills and knowledge students acquire through the learning process. Practical online courses are designed to promote critical thinking, problem-solving, and the application of knowledge in real-world contexts. The study's findings that meta-cognitive skills management and skills engagement positively influence cognitive outcomes align with Bloom's taxonomy, as these educational practices encourage higher-order thinking skills essential for deep learning and academic success (Ormell, 1974).

Conceptual framework

Figure 1. Conceptual framework



This is the conceptual framework of this article; the independent variable is meta-cognitive skills management, the mediating variable is skills management, and the dependent variable is cognitive outcome.

METHODOLOGY

Study design and setting

This study adopted a cross-sectional design with the survey as the instrument. This method facilitates accessing and collecting data and information from the relevant population for the data analysis. The researchers adopted and administered a survey. Specifically, it conducted a cross-sectional survey among Beijing-selected university students who had taken at least one online course. An online questionnaire was distributed to them and used as the primary research tool to collect data on these variables.

Sampling

This study employed multi-stage cluster sampling to discover this educational phenomenon. In line with the model of Krejcie and Morgan (1970) in the case of having a 1 million total study population, 384 is the proper sample for the study. Based on this reference, the present study sent 430 questionnaires, got 400 valid questionnaires. There are 67 universities in Beijing city.

(Jianhong & Tiying, 2013) This study applied MultiStage Cluster Sampling, which consists of 2 stages process Cluster Sampling and Proportional Stratified Random sampling. To choose 3 districts from these districts as the sample location. From each location, this study chose 2 universities. Totally, it chose 6 universities.

From Table 1, The total valid sample from this research is 400—all the participation of university students who took online classes before.

Table 1 The Data of the University Samples

University	Number of students	Number of samples	District
A	16500	68	A District
B	16400	68	A District
C	21000	87	B district
D	14800	61	B district
E	13000	54	C District

F	15000	62	C District
Total	96700	400	

Study instruments

This questionnaire contains four sections. Section A concerns the basic information with students' basic information and 7 questions. In the basic information, the basic features include Gender, Age, Grade, University, Major, Online course attendance, and GRA Ranking. Section B is meta-cognitive skills management with 3 questions (Mohsen Keshavarz et al., 2022). Section C is skills engagement; this section includes 6 questions (Bolliger & Halupa, 2018). Section D is about cognitive outcomes and 5 questions (Zhoc et al., 2020). All of them are mature scales with good reliability and validity. All the items assessed were measured on a five-point Likert scale ranging from 'Strongly Disagree' to 'Strongly Agree".

Table 2 Reliability Analysis for Each Factor

Variable	Number	Alpha
MA	3	0.897
SS	6	0.943
CEO	5	0.953

Meta-cognitive Skills Management (MA) is 0.897, skills engagement is 0.943, and cognitive outcomes is 0.953. These high Alpha coefficients indicate that the measurement tools for these sections have a high level of reliability when assessing their respective concepts.

Table 3 Sum Calculation of the EFA and Validity of the Questionnaire

Variable	KMO	Approximate chi-square	Degree of freedom	P
MA	0.747	667.528	3	0
SS	0.938	2179.472	15	0
CEO	0.919	2060.265	10	0

Table 3 presents the results of the Exploratory Factor Analysis (EFA) and the validity assessment of the questionnaire. The Kaiser-Meyer-Olkin (KMO) values for MA, SS, and CEO are 0.747, 0.938, and 0.919, respectively, indicating satisfactory sampling adequacy for all variables. The approximate chi-square values for MA (667.528, df = 3), SS (2179.472, df = 15), and CEO (2060.265, df = 10) are all statistically significant (P = 0), confirming the validity of the factor structures. These results suggest that the questionnaire has a robust factor structure and is appropriate for further analysis in the study context.

FINDINGS

The findings of this study consist of the demographic profile of respondents and findings for all three objectives.

The demographic profile of respondents

Table 4 *Demographic Profile of Respondents*

Item	Option	No. of students	Percentage
Gender	A. Male	192	48.00
	B. Female	208	52.00
Age	A. 15~20	229	57.25
	B. 20~25	137	34.25
	C. 25~30	34	8.50
Grade:	A. Grade 1	52	13.00
	B Grade 2	158	39.50
	C Grade 3	114	28.50
	D Grade 4	55	13.75
	E. Others	21	5.25
University	A	68	17.00
	B	68	17.00
	C	87	21.75
	D	61	15.25
	E	54	13.50
	F	62	15.50
Major	Arts	37	9.25
	Engineering	180	45.00
	social science	121	30.25
	Others	62	15.50

Item	Option	No. of students	Percentage
Online course attendance:	A. <50%	53	13.25
	B. 50%~70%	170	42.50
	C. 71%~90%	102	25.50
	D >90%.	75	18.75
GPA Ranking:	A. Top 30%	127	31.75
	B. 30% to 70%	243	60.75
	C After 30%.	30	7.50
Total		400	100.0

Table 4 presents the demographic profile of the study's respondents, including a sample of 400 students. The gender distribution is relatively balanced, with 48% male (192 students) and 52% female (208 students). The majority of the respondents fall within the age range of 15-20 years (57.25%, 229 students), followed by 20-25 years (34.25%, 137 students), and a smaller proportion in the 25-30 years age group (8.5%, 34 students). Regarding academic standing, the largest group of respondents are in Grade 2 (39.5%, 158 students), followed by Grade 3 (28.5%, 114 students), Grade 4 (13.75%, 55 students), Grade 1 (13%, 52 students), and others (5.25%, 21 students). The students are distributed across six universities (A-F), with a relatively even distribution among them, and the majority majoring in Engineering (45%, 180 students), followed by Social Science (30.25%, 121 students), Arts (9.25%, 37 students), and others (15.5%, 62 students). In terms of online course attendance, 42.5% (170 students) reported an attendance rate of 50%-70%, while 25.5% (102 students) had a 71%-90% attendance rate, 18.75% (75 students) had more than 90% attendance, and 13.25% (53 students) had less than 50% attendance. Finally, the GPA rankings show that 31.75% (127 students) are in the top 30%, 60.75% (243 students) fall between 30% and 70%, and 7.5% (30 students) are ranked after 70%.

The following elaboration presents the findings for all three research objectives.

H1: Meta-cognitive skills management has a significant effect on skills engagement during online learning in selected universities in Beijing, China

Table 5 Linear regression analysis results of MA and SS

	Regression Coefficient 95% CI		Collinearity Diagnostics	
			VIF	Tolerance
Constant	2.473**(14.356)	2.136 ~ 2.811	-	-
MA	0.276**(5.776)	0.182 ~ 0.369	1.000	1.000
Sample	400			
R^2	0.077			
Adjusted R^2	0.075			
F	$F(1,398)=33.357, p=0.000$			

Regression Coefficient 95% CI
Dependent variable: SS
D-W value: 2.050
** p<0.05 ** p<0.01 The t value is in the brackets*

Table 5 presents a linear regression analysis examining the relationship between metacognitive skills management (MA) and skills engagement (SS). The study includes 400 samples and yields an R-squared value of 0.077, indicating that meta-cognitive skills management can explain 7.7% of the variance in skills engagement. The adjusted R-squared value is slightly lower at 0.075, reflecting the adjustment for the number of predictors in the model.

The regression coefficient for MA is 0.276, with a 95% confidence interval ranging from 0.182 to 0.369, and the associated t-value is 5.776, which is statistically significant at the $p < 0.01$ level. This suggests that metacognitive skills management positively and significantly impacts skills engagement.

Collinearity diagnostics indicate a VIF (Variance Inflation Factor) and Tolerance value of 1.000 each, suggesting no multicollinearity issues. The F-statistic for the overall model is 33.357, with a p-value of 0.000, indicating that the regression model is statistically significant. The Durbin-Watson (D-W) value of 2.050 implies no significant autocorrelation in the residuals. These results support the hypothesis (H1) that metacognitive skills management positively influences skills engagement.

H2.Meta-cognitive skills management has a significant effect on cognitive outcome during online learning in selected universities in Beijing, China.

Table 6 Linear regression analysis results of MA and CEO

	Regression Coefficient	95% CI	Collinearity Diagnostics	
			VIF	Tolerance
Constant	3.182**(18.455)	2.844 ~ 3.520	-	-
MA	0.246**(5.153)	0.152 ~ 0.340	1.000	1.000
Sample	400			
R^2	0.063			
Adjusted R^2	0.060			
F	$F(1,398)=26.549, p=0.000$			

** p<0.05 ** p<0.01 The t value is in the brackets*

The table provides a linear regression analysis of the results examining the relationship between meta-cognitive skills management (MA) and cognitive outcomes (CEO). The regression model includes 400 samples and shows an R-squared value of 0.063, indicating that 6.3% of the variance in cognitive outcomes is explained by meta-cognitive skills management. The adjusted R-squared value is slightly lower at 0.060, reflecting the model's adjustment for the number of predictors.

The regression coefficient for MA is 0.246, with a 95% confidence interval ranging from 0.152 to 0.340, and the associated t-value is 5.153, which is statistically significant at the $p < 0.01$ level. This suggests that metacognitive skills management positively and significantly impacts cognitive outcomes.

Collinearity diagnostics indicate a VIF (Variance Inflation Factor) and Tolerance value of 1.000 each, suggesting no multicollinearity issues. The F-statistic for the overall model is 26.549, with a p-value of 0.000, indicating that the regression model is statistically significant. The Durbin-Watson (D-W) value of 1.890 implies no significant autocorrelation in the residuals. These results support the hypothesis (H2) that metacognitive skills management positively influences cognitive outcomes.

H3: Skills engagement has a significant effect on cognitive outcome during online leaning in selected universities in Beijing, China.

Table7: *Linear regression analysis results of SS and CEO*

	Regression Coefficient	95% CI	Collinearity Diagnostics	
			VIF	Tolerance
Constant	3.017**(17.758)	2.684 ~ 3.350	-	-
SS	0.297**(6.243)	0.203 ~ 0.390	1.000	1.000
Sample	400			
R^2	0.089			
Adjusted R^2	0.087			
F	$F(1,398)=38.980, p=0.000$			

Dependent variable: CEO
D-W value: 1.857
** p<0.05 ** p<0.01 The t value is in the brackets*

The table shows the results of a linear regression analysis examining the relationship between skills engagement (SS) and cognitive outcomes (CEO). The analysis involves 400 samples and yields an R-squared value of 0.089, indicating that 8.9% of the variance in cognitive outcomes is explained by skills engagement. The adjusted R-squared value is slightly lower at 0.087, accounting for the number of predictors in the model.

The regression coefficient for SS is 0.297, with a 95% confidence interval ranging from 0.203 to 0.390, and the associated t-value is 6.243, which is statistically significant at the $p < 0.01$ level. This indicates that skills engagement positively and significantly impacts cognitive outcomes.

Collinearity diagnostics show a VIF (Variance Inflation Factor) and Tolerance value of 1.000 each, indicating no multicollinearity issues. The F-statistic for the overall model is 38.980, with a p-value of 0.000, demonstrating that the regression model is statistically significant. The Durbin-Watson (D-W) value of 1.857 suggests no significant autocorrelation in the residuals. These findings support the hypothesis (H3) that skills engagement positively influences cognitive outcomes.

H4: Skills engagement significantly mediates the relationship between meta-cognitive skills management and cognitive outcome during online learning in selected universities in Beijing, China. Beijing, China.

Table 8: *Mediation effect model test*

	CEO	SS	CEO
Constant	3.182** (18.455)	2.473** (14.356)	2.572** (12.478)
MA	0.246** (5.153)	0.276** (5.776)	0.178** (3.692)
SS			0.247** (5.065)
Sample	400	400	400
R^2	0.063	0.077	0.119
Adjusted R^2	0.060	0.075	0.115
F	$F(1,398)=26.549, p=0.000$	$F(1,398)=33.357, p=0.000$	$F(2,397)=26.923, p=0.000$

** p<0.05 ** p<0.01 In the parentheses, there are t-values.*

** p<0.05 ** p<0.01 In the parentheses, there are t-values.*

The table presents a mediation effect model test examining the relationship between meta-cognitive skills management (MA), skills engagement (SS), and cognitive outcomes (CEO). The first regression model shows the direct effect of MA on CEO, with a coefficient of 0.246 and a 95% confidence interval indicating statistical significance at the $p < 0.01$ level (t-value 5.153). The R-squared value is 0.063, meaning MA explains 6.3% of the variance in CEO, and the adjusted R-squared is 0.060.

The second model examines the effect of MA on SS, showing a significant positive relationship with a coefficient of 0.276 (t-value 5.776). The R-squared value is 0.077, indicating MA explains 7.7% of the variance in SS, and the adjusted R-squared is 0.075.

The third model evaluates the mediation effect, including both MA and SS as predictors of CEO. The coefficient for MA decreases to 0.178 (t-value 3.692), while SS has a significant positive coefficient of 0.247 (t-value 5.065). This model's R-squared value is 0.119, indicating 11.9% of the variance in CEO is explained by both predictors, with an adjusted R-squared of 0.115.

The F-statistics for all models are significant, indicating the models' overall significance. The results support the hypothesis (H4) that skills engagement partially mediates the relationship between meta-cognitive skills management and cognitive outcomes, demonstrating both direct and indirect effects of MA on CEO through SS.

Table 9: *Mediation Test Results - Horizontal Format*

Item	Symbol	Meaning	Effect	95% CI		SE	*z* /*t*	*p*	Result
				Lower	upper				
MA=>SS=>CEO	a*b	Indirect effect	0.068	0.025	0.119	0.024	2.875	0.004	
MA=>SS	a	X=>M	0.276	0.182	0.369	0.048	5.776	0.000	
SS=>CEO	b	M=>Y	0.247	0.151	0.342	0.049	5.065	0.000	Mediation
MA=>CEO	c'	Direct effect	0.178	0.084	0.273	0.048	3.692	0.000	
MA=>CEO	c	Total effect	0.246	0.152	0.340	0.048	5.153	0.000	

The table presents a mediation effect test for the relationship between meta-cognitive skills management (MA), skills engagement (SS), and cognitive outcomes (CEO). It shows the direct, indirect, and total effects of MA on CEO with SS as a mediator.

The indirect effect of MA on CEO through SS is 0.068, with a 95% confidence interval (CI) ranging from 0.025 to 0.119, a standard error (SE) of 0.024, a z-value of 2.875, and a p-value of 0.004. This indicates a significant indirect effect, supporting the partial mediation hypothesis.

The direct effect of MA on SS (path a) is 0.276, with a 95% CI of 0.182 to 0.369, an SE of 0.048, a t-value of 5.776, and a p-value of 0.000. This signifies a strong and significant direct effect of MA on SS.

The direct effect of SS on CEO (path b) is 0.247, with a 95% CI of 0.151 to 0.342, an SE of 0.049, a t-value of 5.065, and a p-value of 0.000, indicating a significant direct effect of SS on CEO.

The direct effect of MA on CEO (path c') is 0.178, with a 95% CI of 0.084 to 0.273, an SE of 0.048, a t-value of 3.692, and a p-value of 0.000, showing a significant direct effect of MA on CEO.

The total effect of MA on CEO (path c) is 0.246, with a 95% CI of 0.152 to 0.340, an SE of 0.048, a t-value of 5.153, and a p-value of 0.000, confirming the overall significant impact of MA on CEO.

These results collectively support the hypothesis that skills engagement (SS) partially mediates the relationship between meta-cognitive skills management (MA) and cognitive outcomes (CEO).

DISCUSSION

The results of this study provide significant fresh angles on the intricate relationships among university students in Beijing, China, between meta-cognitive skills management, skills engagement and cognitive outcomes in the framework of online learning. First, the favorable and significant correlation between metacognitive skills management and skills engagement (H1) is compatible with past studies demonstrating that students who effectively regulate their meta-cognitive skills tend to participate more actively in learning activities. This underlines the requirement of helping students develop their capacity for tracking, planning, and evaluating their learning processes to enhance their general involvement in online learning environments. Good meta-cognitive ability students are more likely to be autonomous learners able to more effectively navigate the challenges of online learning (Spiliotopoulos et al., 2020). Furthermore, the study supports the idea that students skilled at regulating their learning strategies are more likely to attain superior cognitive outcomes by confirming that meta-cognitive skills management significantly impacts cognitive outcomes (H2) (Spiliotopoulos et al., 2020). Moreover, the study confirms that meta-cognitive skills management significantly influences cognitive results (H2), supporting the theory that students adept in controlling their learning techniques are more likely to reach superior cognitive outcomes.

In addition, research shows that higher degrees of engagement, including behavioral, emotional, and cognitive aspects, are linked with improved learning outcomes is consistent with the favorable effect of skills engagement on cognitive outcomes (H3) (Iqbal et al., 2021). Enhancing cognitive outcomes, engaged students are more likely to contribute to conversations, work with peers, and interact extensively with course material. Encouragement of active involvement in online learning activities, such group projects, interactive exercises, and conversations, can significantly improve cognitive results. Teachers should create interesting internet content and offer prompt feedback to keep students interested and motivated. Significantly, the skills engagement partially mediates the relationship between meta-cognitive skills management and cognitive outcomes, underscoring the critical role of student engagement in optimizing the advantages of metacognitive skills on cognitive development (Wang et al., 2022). According to these results, educational frameworks should consider including meta-cognitive skill development by policymakers and curriculum designers. More effective online learning can result from creating courses that encourage cognitive and emotional involvement.

IMPLICATIONS

To assist students in properly negotiating the difficulties of online learning, teachers should include techniques that build their meta-cognitive skills—self-regulation, planning, and monitoring. These techniques help students become more self-directed and competent in controlling their learning processes, improving their academic results.

Cognitive results can be much improved by motivating active engagement in online learning activities, which include conversations, group projects, and interactive assignments. Teachers should create interesting online materials and offer quick comments to keep student interested and driven. In addition to enhancing understanding and memory, active participation helps pupils to feel community and cooperative.

Curriculum designers and policymakers should give meta-cognitive skill development some thought inside their frameworks for instruction. Creating courses that encourage cognitive and emotional involvement can help online learning experiences be more effective. Incorporating components that improve self-regulation and interactive engagement helps courses better support students' academic success and personal development in virtual learning environments.

CONCLUSION

The complex interactions among meta-cognitive skills management, skill engagement, and cognitive results were investigated in this article. The results show that meta-cognitive skills management considerably improves cognitive outcomes both directly and indirectly through skill engagement. Emphasizing its crucial part in the process of cognitive growth, skills engagement acts as a partial mediator.

These results have significant ramifications for policy and the educational process. Teachers should prioritize meta-cognitive skill development and support techniques to increase students' involvement with their abilities. This will help them establish a classroom that fosters the acquisition of knowledge and the growth of critical thinking and problem-solving capacity.

Future studies must continue investigating the dynamic relationships between several learning and cognitive development aspects. Further understanding of how these linkages change over time and the long-term effects of meta-cognitive skills and participation on academic and personal results could emerge from longitudinal studies. Furthermore, looking at the function of other possible mediators and moderators will help us better grasp the routes via which meta-cognitive skills affect cognitive results.

To improve cognitive results, active participation and the development of meta-cognitive abilities are very vital tactics. Including these components in their teaching will help teachers improve their pupils' academic performance and general cognitive development.

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