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Impact of E-Learning Tools on University Students' Learning Outcomes: The Mediating Role of Cognitive Development

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Abstract:- The aim of this study was to explore the impact of E-learning tools on university students' learning outcomes, with a particular focus on examining the mediating role of cognitive development using a cross-sectional research design, the study surveyed 500 graduate students from four different universities in Wuhan, Hubei Province, China. The data were analyzed using the Partial Least Squares Structural Equation Modelling (PLS-SEM) approach. The findings confirmed a significant positive relationship between the use of E-learning tools and students' learning outcomes, and between the use of e-learning tools and cognitive development. Additionally, cognitive development significantly impacted students' learning outcomes. Importantly, cognitive development was found to mediate the relationship between the use of e-learning tools and students' learning outcomes. The study emphasizes the role of cognitive development in enhancing the effectiveness of e-learning tools and encourages their incorporation in university curricula.

Keywords:- *E-Learning Tools, Cognitive Development, Students' Learning Outcomes.*

I. INTRODUCTION

Nowadays, world technology is moving faster than ever. Over the last few decades, new inventions and discoveries have changed how people act and live their lives (Joy, 2020). Internet yields many different ways to talk to each other, find information, shop, and do many other things (Dahan et al., 2022). These technological changes have not only changed the world around, but has also changed the way people live their lives (Gomollón-Bel, 2019). People born in the last few decades of the 20th century, often called "digital natives," have grown up with things like mobile phones, the internet, computers, and video games (Ivanchenko, 2022). Because of the internet, they have learned to do many things at once, prefer pictures and videos over text, and use the internet a lot (Febrianto et al., 2020).

Thompson et al. (2021)Thompson et al. (2021) Thompson et al. (2021)Thompson et al. (2021) has said that the internet has changed how college students live and will affect their futures. He also thinks they couldn't live without it. The internet has become a tool that students can't do without. Even if a student can't afford a personal computer, he/she needs one to do schoolwork, sign up for classes, and find information(Reisdorf et al., 2020). Past studies have found that students mainly use the internet to find information for schoolwork, talk to people, and run websites or social media pages (Tkáčová et al., 2021). For university scholars, the internet serves as a vital instrument aiding them in their learning journey, assisting in tasks such as locating necessary resources, conducting research, performing lab work, and much more (López-Pernas et al., 2019).

Moreover, the current global direction in educational advancement is characterized by the application of information technology skills and knowledge in pedagogical strategies (Mystakidis et al., 2022). E-learning, an all-encompassing educational approach, caters to learners across different age groups, enabling students to pursue their studies tailored to their individual aptitudes (Fawaz & Samaha, 2021). With the internationalization of e-learning,

knowledge acquisition is facilitated to suit students' unique needs, thereby enhancing their competitive edge. The comprehensive utilization of information technology tools can augment learning efficacy, stimulate proactive learning, and foster a lifelong learning aspiration (Osuji & Amadi, 2020).

E-learning tools, including learning management systems, digital textbooks, educational apps, and online course materials, have the potential to provide interactive, personalized, and engaging learning experiences (Huang et al., 2020). Since these tools are becoming more common, it's really important to know how they affect the way students think and learn. Cognitive development refers to the construction of thought processes, including remembering, problem-solving, and decision-making, from childhood through adolescence to adulthood (Pakpahan & Saragih, 2022). It is a critical factor in students' academic performance and overall learning outcomes (Schunk, 2012) while traditional classroom methods have long been studied for their impact on cognitive development in comparison to the latest trends as per the Cognitive Theory of Multimedia Learning (Makransky & Petersen, 2019).

Moreover, the flexible and adaptive learning experiences provided by e-learning tools could foster problem-solving and critical thinking skills (So et al., 2019). The resulting cognitive development can, in turn, influence students' learning outcomes. Enhanced cognitive skills can lead to improved academic performance, better knowledge retention, and the development of practical skills (Peng & Chen, 2019). Therefore, understanding the role of e-learning tools in cognitive development can provide valuable insights into optimizing learning outcomes in the digital age. However, despite the theoretical underpinnings suggesting the potential benefits of e-learning tools, empirical evidence exploring the impact of these tools on cognitive development and subsequent learning outcomes remains sparse. There is a particular need for research investigating the mediating role of cognitive development in the relationship between the use of e-learning tools and students' learning outcomes. This study aims to address this gap in the literature by exploring the impacts of e-learning tools on cognitive development and students' learning outcomes.

A number of research studies have been conducted pertaining to the connection and impact of e-learning tools on students' learning outcomes across different countries (Sriwiyanti et al., 2022). The literature demonstrates that less focus has been given by the scholars to explore three-way relationship among the variables, especially in emerging countries such as China, which could yield novel insights. Therefore, this study explored the three-way interrelationship among the variables such as E-learning tools, students' learning outcome, and for indirect influence cognitive development used as a mediator variable between them, (see figure 1). Moreover, the current research has been focused on the following research questions:

- RQ1: How do e-learning tools and cognitive development influence students' learning outcomes?
- RQ2: How does cognitive development mediate the relationship between e-learning and students learning outcome

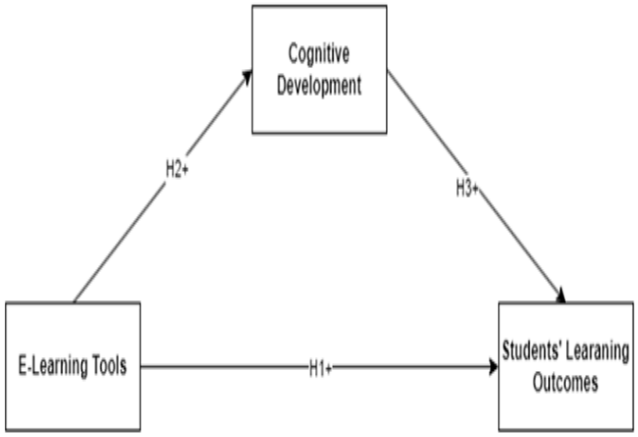

Fig 1Research Model

➢ *E-Learning Tools*

E-Learning tools refer to digital technologies and platforms that are designed to support and enhance the learning process through online delivery of educational content, interactive activities, and communication features (Kumar & Sharma, 2021).

E-Learning tools provide opportunities for interactive and collaborative learning experiences. Research by Wu et al. (2022)Wu et al. (2022)Wu et al. (2022) demonstrated that e-learning tools, such as online discussion forums and collaborative platforms, foster active student engagement and promote peer interaction. These tools facilitate knowledge sharing, collaborative problem-solving, and constructive feedback exchange among students (Themelis & Sime, 2020). Furthermore, e-learning tools offer real-time communication features, such as video conferencing and instant messaging, which enable synchronous interactions between instructors and students, enhancing the sense of community and social presence within the online learning environment.

➢ *Students Learning Outcome*

Students' learning outcomes refer to the measurable knowledge, skills, attitudes, and competencies that students are expected to acquire or develop as a result of their educational experiences. These outcomes serve as benchmarks to assess the effectiveness of teaching and learning strategies. Research has shown that well-defined learning outcomes enhance student engagement and achievement (Ayadat et al., 2020). For example, in a study conducted by Hong et al. (2020)Hong et al. (2020)Hong et al. (2020)Hong et al. (2020) on undergraduate biology students, it was found that clearly articulated learning outcomes led to improved performance and increased motivation among students. When students have clear understandings of their learning objectives and the methods of assessment, they are more inclined to engage proactively in their educational journey. This clarity enables them to establish suitable goals and track their development effectively.

➢ *Cognitive Development*

Cognitive development refers to the gradual process through which individuals acquire and refine their cognitive abilities, including perception, attention, memory, problem-solving, and decision-making, it involves the progressive improvement of cognitive skills and the acquisition of knowledge, enabling individuals to think, reason, and understand the world around them (Drigas & Mitsea, 2020). In an educational context, students' cognitive development encompasses the intellectual growth and advancement of students within the learning environment. It involves the enhancement of critical thinking skills, information processing, and the development of metacognitive strategies that enable students to effectively plan, monitor, and evaluate their own learning progress (Alsaleh, 2020). Students' cognitive development is influenced by various factors, including educational practices, instructional methods, social interactions, and individual experiences, all of which contribute to shaping students' cognitive abilities and facilitating their overall learning outcomes (Alam, 2022).

➢ *E-Learning tools and Students' Learning Outcomes*

The correlation between e-learning tools and students' academic outcomes has captured the attention of numerous researchers. The prevailing view among them is that, when leveraged effectively, these tools can notably augment learning outcomes. A standout study among these is Yoon et al. (2021)Yoon et al. (2021)Yoon et al. (2021)Yoon et al. (2021), which discovered that e-learning instruments such as video lectures and online discussion forums can catalyze deeper comprehension and heighten student engagement. Such tools provide the students the liberty to learn at their own speed, thereby permitting them to revisit and tackle complex concepts as required. It was concluded in the study that this flexibility and adaptability could enhance comprehension and retention of the material (Kokoç, 2019).

In a similar study Salloum et al. (2019)Salloum et al. (2019)Salloum et al. (2019)Salloum et al. (2019) found that the use of e-learning tools could lead to improved learning outcomes the outcomes were measured in terms of higher grades, a more thorough understanding of the subject matter, and increased student satisfaction. The researchers concluded that the integration of e-learning tools in the educational process could significantly enhance academic performance and overall learning experience (Kokoç & Altun, 2021). Therefore, this study explores the impact of E-learning on students learning outcome and the following hypothesis was formulated for this purpose:

- *H1: There is a significant and positive relationship between use of E-learning tools and students' learning outcomes.*

➢ *E-Learning tools Cognitive Development of students*

E-learning tools have been found to significantly impact the cognitive development of students specifically, these can promote critical thinking skills, problem-solving abilities, and self-regulated learning (Lai & Hwang, 2021). E-learning tools can foster critical thinking skills by encouraging students to analyze information, contemplate on different perspectives, and construct well-reasoned arguments (Grant, 2020). E-learning tools can also stimulate critical thinking, as university students must evaluate and synthesize information from a variety of sources (Jaswal & Behera, 2023).

In terms of problem-solving abilities, e-learning tools, such as interactive simulations and games, can play a crucial role (Sotiriou et al., 2020). These platforms provide students with virtual scenarios that often require the application of learned concepts to resolve complex problems. This active engagement not only solidifies understanding but also enhances problem-solving skills(Veldkamp et al., 2020). Further research by Wang et al. (2022)Wang et al. (2022)Wang et al. (2022)Wang et al. (2022) confirms the positive impact of educational games on problem-solving abilities. Based on literature part another hypothesis was purposed.

- *H2: There is a positive and significant correlation between use of E-learning tools and cognitive development.*

➢ *Cognitive Development and Students Learning Outcome*

Cognitive development, a key aspect of students' growth, refers to the transformation of a learner's abilities and skills concerning knowledge acquisition, problem-solving, and information processing. This development influences students' learning outcomes significantly (Mcleod, 2022). According to Piaget's cognitive development theory, students pass through distinct stages of cognitive growth: sensorimotor, preoperational, concrete operational, and formal operational—each of which shapes their ability to understand and interact with the world (Piaget, 1952). As students' progress through these stages, their learning outcomes in terms of knowledge acquisition, comprehension, and application improve. They become capable of more complex thought processes and problem-solving, leading to enhanced academic performance (Taub et al., 2020).

Moreover, research has highlighted the critical role of cognitive development in the learning process. For instance, a study by Lara and Bokoch (2021)Lara and Bokoch (2021)Lara and Bokoch (2021)Lara and Bokoch (2021) found a significant correlation between working memory, a crucial cognitive ability, and learning outcomes in students. Working memory is responsible for the temporary storage and manipulation of information, and it significantly influences comprehension, learning, and reasoning skills (Angelopoulou & Drigas, 2021). In conclusion, cognitive development, encompassing aspects like working memory and critical thinking, plays a crucial role in shaping students' learning outcomes. As cognitive abilities develop and mature, students are better equipped to process information, solve problems, and hence achieve improved academic outcomes (Ludyga et al., 2022). Based on literature part another hypothesis was purposed.

- *H3: Cognitive development has a positive and significant relationship with students' learning outcomes.*

➢ *Mediating Role of Cognitive Development in the Relationship between the Use of E-Learning Tools and Students' Learning Outcomes.*

Cognitive development plays a mediating role in the relationship between the use of E-learning tools and students' learning outcomes (Dal Santo et al., 2022). E-learning tools, such as online discussion forums and interactive simulations, have been found to stimulate cognitive abilities like critical thinking and problem-solving this cognitive stimulation, in turn, improves learning outcomes (KIM et al., 2013). For instance, the asynchronous nature of online discussions promotes reflection, a critical cognitive skill, which then leads to deeper understanding and better retention of academic material (Gao et al., 2009). Similarly, interactive simulations enhance problem-solving abilities, leading to better application of learned concepts (Yang & Chang, 2013). Moreover, E-learning environments promote self-regulated learning, an essential cognitive skill for effective learning, which is linked to improved academic performance (Inan et al., 2017). Thus, cognitive development serves as a critical mechanism through which e-learning tools influence students' learning outcomes. Thus, the current study aimed to widening this gap by exploring the mediating role of cognitive development among aforementioned variables through the following hypothesis:

- *H4: Cognitive development mediates the relationship between the use of E-learning tools and students' learning outcomes.*

II. RESEARCH DESIGN

In this study, a cross-sectional quantitative research approach will be employed. A cross-sectional research design is a form of observational study that examines data derived from a population, or a representative subset, at a specific point in time. It provides a 'snapshot' of the variables of interest at a given point. In this study, the variables of interest are e-learning tool usage, learning outcomes, and cognitive development.

➢ *Instrument Development*

In this study, E-learning was examined as the independent variable, students' learning outcome as a dependent variable and, cognitive development attended as the mediator variable. For the collection of required data, a questionnaire was designed consisting of two parts. The first part consisted demographic information such as; gender, year of study, and major of the respondents. Additionally, this section included instructions, as well as statements ensuring anonymity and privacy. While in the second part, respondents were required to rate the given item related to E-learning, students' learning outcome, and students' cognitive development. There were six items for each construct. The multi-point Likert scale was used ranging from strongly disagree to strongly agree. The reliability of the scale was measured by using a threshold value of 0.07. Additionally, Table 2 provides information on the convergent and discriminant validity of the variables.

➢ *E-Learning*

In this study eight statements related to E-learning were adapted from the work of (Al-Fraihat et al., 2020). It was five-point Liker type scale having response range from one to four "Strongly Disagree to Strongly Agree". The Sample statements used were: "I frequently use e-learning tools for my academic studies; I find e-learning tools to be helpful in enhancing my understanding of course material; and I find it easy to navigate and use e-learning tools". The E-learning scale adapted for this research was valid and has acceptable internal consistency, where the Cronbach's Alpha value was 0.657.

➢ *Students' Learning Outcomes*

In this study eight statements related to students' learning outcomes were adapted from the work of (Al-Fraihat et al., 2020). It was five-point Liker type scale having response range from one to five "Poor to Excellent". Where Sample statements were: "I perceive my learning outcome in Mathematics through e-learning to be; how do you perceive your learning outcome in English Language through e-learning; and how would you rate your learning outcome in Social Studies through e-learning". The students learning scale adapted for this research was valid and has acceptable internal consistency, where the Cronbach's Alpha value was 0.657.

➢ *Cognitive Development*

In this study seven statements related to cognitive development adapted from the work of Schraw and Dennison (1994) It was five-point Liker type scale having response range from one to five "1 being "Strongly Disagree" and 5 being "Strongly Agree". Additionally, the scales fall under two broader categories: Knowledge of Cognition and Regulation of Cognition. Example of statements are as: "I understand my intellectual strengths and weaknesses. I ask myself questions about how well I am doing while I am learning something new, and I change strategies when I fail to understand. I am aware of what strategies I use when I study, "Coefficient alphas for items loading on each factor reached .91, indicating a high degree of internal consistency. Coefficient alpha for the entire instrument reached .95.

➢ *Sampling and Data Collection*

The target population for the present study consisted of graduate students enrolled in targeted universities (Huazhong university of science and technology, Wuhan university of science and technology, China university of geoscience, and Wuhan university located in Wuhan, Hubei Province China. These universities were nominated based on their academic record, and student population size. Stratified random sampling technique used to select the participants for this study; specifically, students were selected by random sampling from each university. In total 500 students were selected as sample of this study.

Table 1 Demographic Details

Personal attributions	Categories	Frequency (n)	Percentage (%)
Gender	Male	250	50
	Female	250	50
	Total	500	100
Age	18- 20 Years	150	30
	21 to 25 Years	150	30
	26 to 30 Years	200	40
	Total	500	100
Major	Humanities	100	20
	Engineering	150	30
	Science	250	50
	Total	500	100
Location	Rural	250	50
	Urban	250	50
	Totao	500	100

Table 1 presents demographic information across various personal attributes. The sample consisted of 500 individuals, evenly split between males and females, indicating a perfect gender balance in the group. The ages of the participants fall within three brackets: 18-20 years, 21-25 years, and 26-30 years, with the largest group (40%) being those aged 26 to 30 years. The remaining two age groups each make up 30% of the sample. The sample comprises individuals from different educational backgrounds. Half of them (50%) majored in science, while 30% studied Engineering, and the remaining 20% are Humanities graduates. Regarding the location, the sample is evenly distributed, with half residing in rural areas and the other half in urban areas. The collected data were sufficient to apply Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS 3 statistical software. Further details regarding the demographic profile of the participants can be found in **Table 1.**

➢ *Measurement Models*

In this study, the SmartPLS 3 statistical software was used by researchers to carry out confirmatory factor analysis for calculating the measurement models at first stage of data analysis the researcher revealed that variance-based structural equation modeling (PLS-SEM) is less sensitive than covariance-based structural equation modeling (PLS-SEM), the reliability and validity of the measurement scale assessed by authors at initial stage (**Table 2** presenting further details). To determine the reliability index in this study measured mentioned indicators; Cronbach's Alpha, factor loading, rho A, and composite reliability.

All given indicators had specific criteria of threshold where the value is 0.07 for the most of the indicators, similarly the value of AVE index was above 0.50, hence the scale discriminant validity of all scales was adequate. As it should be high or greater than 0.50 discussed by Zheng et al. (2022). AVE technique was used to measure the convergent validity. The details of reliability and threshold value of the other indicators presented in Table 2; therefore, the scale was valid and reliable to collect data.

Table 2 Reliability and Validity

Scales	Factor loading	Cronbach's Alpha	Rho_A	Composite reliability	AVE
E-Learning Tools (ELT)		0.887	0.889	0.912	0.598
EL1	0.725				
EL2	0.749				
EL3	0.752				
EL4	0.737				
EL5	0.786				
EL6	0.825				
El7	0.83				
Students' Learning Outcomes (SLO)		0.9	0.903	0.921	0.626
SLO1	0.781				
SLO2	0.772				
SLO3	0.778				
SLO4	0.823				
SLO5	0.716				
SLO6	0.834				
SLO7	0.829				
Cognitive Development (CD)		0.864	0.869	0.897	0.593

CD1	0.742				
CD2	0.776				
CD3	0.746				
CD4	0.794				
CD5	0.801				
CD6	0.761				

Table 2 showed the results of a reliability and validity analysis on three different scales: E-Learning Tools (ELT), Students' Learning Outcomes (SLO), and Cognitive Development (CD). Each scale's reliability is measured using Cronbach's Alpha and Rho_A, with values for all scales being relatively high, indicating strong internal consistency. Composite reliability is also evaluated, demonstrating acceptable consistency across the individual scales. Furthermore, the Average Variance Extracted (AVE) suggests satisfactory construct validity for each scale. Factor loadings, indicating the strength of the relationship between the latent variable and its indicators, are also shown for each individual item on the scales. These loadings are all above 0.7, indicating a substantial relationship between each item and its corresponding construct.

Table 3 Discriminant Validity

Constructs	CD	ELT	SLO
Cognitive Development (CD)	0.77		
E-Learning Tools	0.402	0.773	
Students' Learning Outcomes (SLO)	0.457	0.82	0.791

Table 3 presented the discriminant validity of three constructs: Cognitive Development (CD); E-Learning Tools (ELT); and Students' Learning Outcomes (SLO). Discriminant validity refers to the extent to which these constructs are distinct from each other (Trochim, 2006). The diagonal values (0.77 for CD, 0.773 for ELT, and 0.791 for SLO) represent the square root of the average variance extracted (AVE), a measure of the amount of variance that is captured by the construct in relation to the amount of variance due to measurement error (Fornell & Larcker, 1981). The off-diagonal values represent the correlations between constructs. For good discriminant validity, the diagonal values (sqrt AVE) should be higher than the off-diagonal values in the corresponding rows and columns (Hair Jr, et al., 2010). In this case, each construct demonstrates satisfactory discriminant validity as the AVE square root for each construct is larger than its correlation with the other constructs.

Table 4 Co-Linearity and Model Fit

Constructs	CD	ELT	Model Fit	
Cognitive Development (CD)	0.77		SRMR	0.073
E-Learning Tools	0.402	0.773	NFI	0.780
Students' Learning Outcomes (SLO)	0.457	0.82		

Table 4 presents information on co-linearity and model fit for three constructs: Cognitive Development (CD), E-Learning Tools (ELT), and Students' Learning Outcomes (SLO). Co-linearity refers to the degree to which two predictors in a model are correlated (Dormann et al., 2013). In this case, the CD and ELT have a correlation of 0.402, while CD and SLO have a correlation of 0.457, indicating a moderate level of collinearity. The model fit indices listed are the Standardized Root Mean Square Residual (SRMR) for CD with a value of 0.073 and the Normed Fit Index (NFI) for ELT with a value of 0.780. SRMR is a goodness-of-fit statistic, with values less than 0.08 generally indicating good fit (Hu & Bentler, 1999), while NFI values above 0.90 typically indicate a good fit (Sahoo, 2019), suggesting that the model fit for ELT may need improvement.

Table 5 R-Square

Constructs	R-square	R-square adjusted
Cognitive Development (CD)	0.161	0.16
Students' Learning Outcomes (SLO)	0.691	0.69

Table 5 shows the values of R-square and R-square adjusted for two conceptual domains: Cognitive Development (CD) and Students' Learning Outcomes (SLO). The R-square, also referred to as the coefficient of determination, is a statistical tool signifying the proportion of variance in a dependent variable that is accounted for by one or more independent variables in a regression model (Cohen, 2013). For CD, the R-square is 0.161, suggesting that the model explains 16.1% of the variance in the dependent variable. For SLO, the R-square stands at 0.691, indicating that the model accounts for 69.1% of the variance in the dependent variable. The adjusted R-square, a variation of R-square that compensates for the quantity of predictors in the model Campos et al. (2021)Campos et al. (2021)Campos et al. (2021)Campos et al. (2021) exhibits values of 0.16 for CD and 0.69 for SLO, demonstrating a

negligible effect from the quantity of predictors in the model.

Table 6 F-square

Constructs	CD	ELT	SLO
Cognitive Development (CD)			
E-Learning Tools (ELT)	0.193		1.562
Students' Learning Outcome (SLO)			

Table 6 showed the F-square values for the relationships among the constructs of Cognitive Development (CD), E-Learning Tools (ELT), and Students' Learning Outcomes (SLO). F-square acts as a determinant of effect size within a structural equation model, and is employed to ascertain the potency of the correlation between constructs (Ben-Shachar et al., 2020). The F-square for the association between CD and ELT is 0.193, demonstrating a small to medium effect size according to the guidelines laid out by Ben-Shachar et al. (2020)Ben-Shachar et al. (2020)Ben-Shachar et al. (2020)Ben-Shachar et al. (2020) Conversely, the F-square value for the link between ELT and SLO is 1.562, suggesting a large effect size. The interpretation of these values is that ELT significantly influences both CD and SLO, having a more pronounced impact on SLO.

Table 7 Direct Relations

Direct Relations	Coefficients	Mean	Standard Deviation	T Statistics	P Values	Decisions
Cognitive Development -> Students' Learning Outcomes	0.152	0.151	0.034	4.538	0.000	Accepted
E-Learning Tools -> Cognitive Development	0.402	0.403	0.050	7.984	0.000	Accepted
E-Learning Tools -> Students' Learning Outcomes	0.758	0.759	0.030	25.242	0.000	Accepted

Table 7 shows the findings from a structural equation modeling evaluation that investigates the direct interconnections between Cognitive Development (CD), E-Learning Tools (ELT), and Students' Learning Outcomes (SLO). The coefficients denote the calculated direct impacts, with ELT exerting a potent direct influence on SLO (0.758) and moderate impacts on CD (0.402). Conversely, CD presents a lesser direct effect on SLO (0.152). These impacts are all statistically meaningful as shown by the T-statistics (with values exceeding 1.96 being deemed significant at the 0.05 level, according to Ben-Shachar et al. (2020)Ben-Shachar et al. (2020)Ben-Shachar et al. (2020) a and p-values (values under 0.05 signify significance, as per, Kennedy-Shaffer (2019)Kennedy-Shaffer (2019)Kennedy-Shaffer (2019)Kennedy-Shaffer (2019). The values of the mean and standard deviation represent the average and spread of these coefficients across possible multiple iterations of the model. The 'Decisions' column confirms that all these relationships were statistically significant, leading to the acceptance of the hypothesis for each connection.

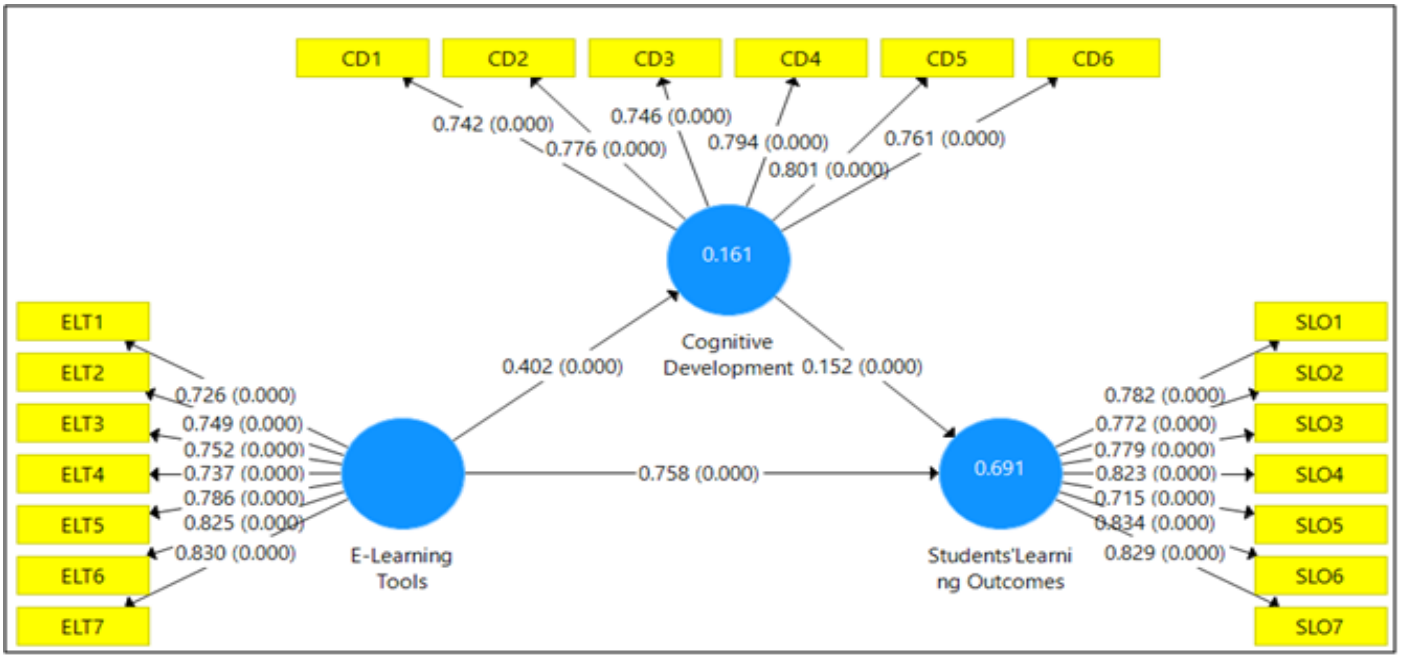

Fig 2 Research Output Model.

Table 8 Indirect Relations

Indirect Relations	Coefficients	Mean	SD	T statistics	P values	Decisions
E-Learning Tools -> Cognitive Development-> Students' Learning Outcomes	0.066	0.066	0.017	3.822	0.000	Accepted

Table 8 shows the results of a structural equation modeling analysis examining the indirect relationship from E-Learning Tools (ELT) to Students' Learning Outcomes (SLO) through Cognitive Development (CD). The coefficient represents the estimated indirect effect, with ELT having a moderate indirect effect on SLO through CD (0.066). This effect is statistically significant as indicated by the T-statistic of 3.822 (values greater than 1.96 are considered significant at the 0.05 level, Cohen, 1988) and a p-value of 0.000 (less than 0.05 indicating significance, (Kennedy-Shaffer, 2019). The mean and standard deviation values reflect the average and variability of these coefficients across potentially multiple runs of the model. The 'Decision' column indicates that this indirect relationship was found to be statistically significant, and thus the hypothesis for this relationship was accepted.

III. DISCUSSION

As the digitization of education progresses, e-learning tools are gaining increased attention due to their potential to transform traditional pedagogical approaches. The adoption of these tools has been expedited by recent global events; The COVID-19 pandemic led to a quick switch to online learning platforms. Despite their widespread use, it is important to evaluate how e-learning tools affect university students' learning outcomes. (Demuyakor, 2020). E-learning tools use digital apps and platforms to make learning easier. They include various technologies like Learning Management Systems (LMS), digital course materials, online quizzes, and discussion forums. (Gonzalez-Sanmamed et al., 2020). Many studies show that e-learning tools improve accessibility and flexibility in education, allowing students to learn at their own speed and convenience. (Zhang et al., 2020).

However, the effectiveness of e-learning tools cannot be solely attributed to their characteristics. Research indicates that cognitive development plays a critical role in mediating the impact of these tools on learning outcomes (Gaffas, 2023). Cognitive development refers to the construction of thought processes, including memory, problem-solving, and decision-making, from childhood through adolescence to adulthood (Garcia & Pereira, 2019). E-learning tools can potentially enhance cognitive development through active engagement, interactive learning, and fostering critical thinking. For instance, discussion forums can stimulate cognitive development by facilitating thoughtful reflections and peer interactions (Islam et al., 2022). Similarly, multimedia presentations can foster information processing skills, and virtual simulations can enhance problem-solving abilities (Baran, 2019). Notwithstanding the potential benefits, the effectiveness of e-learning tools largely depends on their design and implementation. Suboptimal design of these tools can potentially lead to cognitive overload, impeding the learning process (Shin & Song, 2022). Furthermore, without adequate digital literacy and self-regulation, students might struggle to effectively navigate through these tools (García Botero et al., 2021).

Hence, when integrating e-learning tools, it becomes crucial to take into account the cognitive development level of students. Educators should strive to establish a harmonious equilibrium between offering guidance and fostering independence. Moreover, they should explore the incorporation of scaffolding techniques, as these can assist in cognitive development by providing structure and gradually diminishing support as the learner gains proficiency. (Mcleod, 2022). In order to optimize the efficacy of e-learning tools, it is essential for future research to concentrate on formulating strategies that enhance cognitive development. Investigations could delve into the influence of personalized learning plans, guided inquiry, and peer feedback, as these approaches hold significant potential for fostering cognitive growth. By exploring these areas, we can further expand our understanding of how to promote effective cognitive development within the realm of e-learning. (Brooks et al., 2019).

To sum up, e-learning tools possess the capability to enrich the learning outcomes of university students. Nevertheless, the extent of their effectiveness relies on the cognitive development of the learners. Hence, it is imperative for educators to meticulously take into account the cognitive development of the students when designing and implementing e-learning tools. By doing so, they can ensure that the learning outcomes are maximized to their full potential.

IV. CONCLUSION

This study has shed light on the critical role of e-learning tools in enhancing university students' learning outcomes, emphasizing their impact not only directly but also indirectly through the mediation of cognitive development. The findings of this research substantiate the positive relationship between the use of e-learning tools and learning outcomes. More importantly, they illuminate the mediating role of cognitive development in this relationship. Cognitive development was found to play an integral role in this dynamic, underscoring its importance in educational processes. The use of e-learning tools positively influenced students' cognitive development, which, in turn, significantly contributed to improving their learning outcomes. These findings show the notion that e-learning tools can be an essential asset to foster cognitive growth and, consequently, enhance learning performance in university students.

Therefore, universities and educational stakeholders are strongly encouraged to integrate e-learning tools into their curricula. These tools, if effectively used, can boost students' cognitive development and, in turn, significantly enhance their learning outcomes. Furthermore, this integration of e-learning tools into the learning process is of particular relevance in the current digital era where remote and online learning have become increasingly significant.

➢ *Practical Implication*

The research findings underline significant practical implications for educators and universities in the digital era. By embracing e-learning tools and incorporating them into curriculum design, universities can stimulate cognitive development in students, enhancing their learning outcomes. This implies that it's not merely the use of e-learning tools, but their thoughtful integration that contributes to improved learning outcomes, emphasizing the importance of pedagogical approaches in e-learning. Therefore, educators should focus on effectively implementing e-learning tools that promote active learning, critical thinking, problem-solving, and other aspects of cognitive development. Moreover, considering the mediating role of cognitive development in the relationship between e-learning tools and learning outcomes, educational institutions might need to provide additional support for students who may have difficulties in this area to ensure they also benefit from e-learning tools.

➢ *Limitations with future research directions*

Despite the significant findings of this study, there are several limitations which open avenues for future research. This study predominantly focused on university students, and thus the results may not be generalized across different age groups or learning contexts, such as K-12 or vocational education. Future studies might explore the impact of e-learning tools across a more diverse range of educational settings. Furthermore, given the rapid advancement in technology and AI-driven learning tools, the dynamic nature of e-learning calls for continuous examination of these relationships as new tools and technologies emerge. Future studies could also explore the longitudinal effects of e-learning tools on cognitive development and learning outcomes, shedding light on the long-term impact of these tools on student learning.

➢ *Data Accessibility and Availability Statement*

The study includes the authors' original work, that could be found in the article or additional material. If more information is needed, interested parties can contact the corresponding authors.

➢ *Statement on Ethics*

Huazhong University of Science & Technology's Ethics Committee examined and approved this work.

➢ *Contribution of the Author(S)*

Each author mentioned has contributed significantly, directly, and intellectually to the work and all authors have provided their approval for its publication.

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