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Effectiveness evaluation and application of large language model in data-driven teaching decision-making

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ABSTRACT

This study aims to examine teachers' perceptions of the effectiveness of large language models (LLM) in supporting data-driven decision-making in educational contexts. Specifically, the study explores the influence of technological pedagogical knowledge, technological content knowledge, and technological pedagogical content knowledge on teachers' utilization of LLMs for informed decision-making. Additionally, it investigates the moderating role of ethical considerations in the use of LLMs. A survey-based methodology was employed to collect data from university teachers in Chengdu, Sichuan, China, resulting in a sample of 319 respondents, which was analyzed using Smart PLS 4. The findings indicate that technological pedagogical knowledge, technological content knowledge, and technological pedagogical content knowledge for LLM use significantly impact data-driven decision-making in teaching. Moreover, ethical considerations were found to significantly moderate the relationship between these knowledge domains and data-driven decision-making. This study contributes novel insights by addressing the evaluation and application of LLM effectiveness from teachers' perspectives, ultimately fostering the advancement of quality education.

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1. INTRODUCTION

In modern times, the education system, like other fields, utilizes newly developed technology to enhance learning and performance [1]–[3]. The advancement in technology has changed the traditional trends in learning where the performance of teachers is improved. This technology is helpful to design the curriculum for the students and bring effectiveness to their performance [4]. However, the effective use of technology is necessary for the teachers to boost their learning [5]. The development of large language models (LLM) such as ChatGPT have significant importance in the modern education system [6], [7]. The teachers use LLM to design different activities and tasks for the students. Furthermore, the databases of educational institutions have all the records of the students which can be analyzed by using these LLM tools [8]. Higher education institutions are also working on these modules to upgrade their working which is required significantly to improve the performance in critical way. The teachers are trained to use LLM properly as it requires significant experience [9], [10]. The information and statistics outcomes based on

LLM has a significant impact on the learning of students when they are instructed by well qualified teachers [11]. Hence, the role of LLM is significant even in higher education.

The educational institutions in China are also using LLM programs to improve the learning of their students [12]. The use of LLM is necessary for the teachers to boost their performance effectively [13]. Apart from LLM used in designing class activities, it is also used by teachers to analyze the data related to students and course content which is significant for decision making [14]. Data based decision making is always useful for the students to improve their learning which is based on the capabilities of teachers. The pedagogical knowledge and content knowledge of the teacher has significant importance which improves their learning performance critically [15]. When the teachers know the way to use LLM and artificial intelligence (AI) effectively, they are in a better position to make decisions. Similarly, decisions based on data are important to improve the overall performance [16]. In China, many teachers are using LLM for examination of the students and they extended its use to evaluate overall performance of the students. It is necessary for universities teachers to utilize LLM in a proper way to understand its effectiveness in the way of performance [17]. However, there is little known about the role of teachers' pedagogical knowledge and content knowledge in effectiveness in the application of AI in China.

The prior studies discussed that LLM based AI tools are effective to improve the performance of teachers [18]. Furthermore, the study Sharadgah and Sa'di [11] discussed that when teachers are supportive to improve the learning of students, they should know the proper use of AI. The study by Juan and Wei [19] pointed out that effectiveness in the use of AI is possible when teachers are properly trained for it and they know the ethical use of it. According to Dai and Ke [20], the teachers can use LLM for better learning of the students after designing the classroom based activities. However, evaluation of proper use of LLM is still challenging which need significant attention paid by the teachers. In addition, Alam [21] concluded that the teachers can improve their overall performance in the classroom activities with the help of AI use which is necessary for significant performance. On the other hand, Jochim and Lenz-Kesekamp [22] discussed that the use of AI is helpful for the teachers to improve their performance, but they should have appropriate knowledge about the ethical use of it, because unethical use can lead to misleading data and decision making. Although the existing studies in the body of knowledge discussed significant information about the use of LLM for teachers, there are limited studies that discussed the impact of teachers' pedagogical and content knowledge on data driven decision making [23], [24]. Hence, this knowledge gap need significant attention and following question is developed: How the teachers believe of LLM is effective for their data driven decision making?

To address this question, the objective of this study was to test how teachers believe LLM is effective for their data driven decision making. For this objective, the study investigates the impact of technological pedagogical knowledge, technological content knowledge and technological pedagogical content knowledge for LLM use on data driven decision making. The study also investigates the moderating role of ethics in LLM use. The study used primary data and collected data from universities teachers to achieve its objective. The research found that technological pedagogical knowledge, technological content knowledge, technological pedagogical content knowledge for LLM use have a significant impact on data driven teaching decision making. The study also found that moderating interaction of ethics in use of LLM is also significant between the relationship of technological pedagogical knowledge, technological content knowledge, technological pedagogical content knowledge and data driven decision making. This study has novel findings as findings about the effectiveness evaluation and application regarding the use of LLM is discussed from the perspective of teachers. The recommended findings of this study can be used by the teachers to use LLM further in decision making. It can lead to a meaningful change in education section where data driven decision making helps for efficiency. The rest of study is divided into the review of literature, methodology of research, analysis of data, findings, implications and future directions.

2. LITERATURE REVIEW

The use of LLM by teachers is significant to improve their understanding about the information about the students [5]. When the teachers are motivated to support the students, they use LLM or other AI based technologies in the class. The classroom activities of the teachers are also designed by the use of LLM where they formulate the structure of teaching, the selection of content and way of expecting outcome of the students [11]. The knowledge about the curriculum development and overall teaching process helps the teachers to develop their positive attitude towards the students. It helps the students to understand the dynamics of their learning and overall decision making [25]. The instructors are also recommended to motivate the students for the use of AI based technologies for their learning and performing different classroom activities. It has an impact on the performance of the students, which is improved over time [26]. However, the teachers who are using data from students to analyze it, should use LLM for the purpose of

decision making [27]. When the data is analyzed properly and available to the students, it improves their performance effectively which helps to deal with significant challenges [28]. However, the teachers should be motivated to use AI properly, which is necessary in modern times to improve their performance. Thus, the first hypothesis (H1) is formulated as: there is a relationship between technological pedagogical knowledge for LLM application use and data driven decision making.

Knowledge of the course content is important for the teachers, which has an impact on their learning and performance [26]. The use of LLM based technology is helpful for teachers to apply their knowledge into the classroom activities. The schedule development and teaching methodology related help can be accessed from the use of LLM [29]. The training of the teachers is necessary for this purpose to motivate them for the use of technology which has an impact on their performance and improvement [30]. The use of AI technology is also helpful in improving the teaching performance because it assist in different designs [25]. The use of AI is also helpful for teachers to advance their teaching skills by developing new ideas based on the characteristics of the students [31]. When the fair use of technology is processed by the teachers, it improves the effectiveness of their work and sustainable performance. Furthermore, the language related modules are useful to analyze the data related to the class which helps the teachers to decide about the future outcomes of the course content [32]. In this way, there is significant importance of course content to advance its application for the learning performance of the students. Thus, the second hypothesis (H2) of the study is: there is a relationship between technological content knowledge for LLM application use and data driven decision making.

The role of teaching knowledge including the content information is significant for the teachers to improve the productivity in the performance of students [33]. When the teachers are highly motivated, they support the students to effectively increase their performance. Therefore, the use of AI is also improved with the help of teachers and performance of students [34]. It is necessary for the teachers to collectively improve their performance, which has a significant impact on their decision making [35], [36]. It is necessary for the teachers to use LLM or other technology related applications to analyze the information about the students [37]. As far as the performance of the students is concerned, the teachers are highly motivated to use AI related tools. The application of AI related tools is supportive to arrange the data of students and evaluate their performance [38]. Furthermore, content knowledge is also important for the teachers to improve their learning as it has impact on their decision. Whereas the use of LLM is supportive to the students to effectively increase their performance which is necessary for learning of students [39]. The teachers are responsible for effective use of LLM which improves the strategies of their teaching [40]. For this purpose, the higher education institutions management should provide effective training to the students. Thus, the third hypothesis (H3) of the study is: there is a relationship between technological pedagogical content knowledge for LLM application use and data driven decision making.

The use of AI based technology should be based on ethical principles which is helpful in educational institutions [31]. It is necessary for the teachers to have proper training about the ethical principles for the use of technology. The generative LLM related technology can be used by the teachers in a misleading way which has no impact on the application by the teachers [41]. Therefore, the teachers are recommended to work significantly to improve the application of LLM. Although the teachers have information about the content knowledge but sometimes, they have limited information about the use of AI in academic discipline [42]. In this way, the teachers are recommended to boost the use of AI but they should be following all the ethical standards. A useful way of following ethical standards in the application of technology would be a significant way forward for the teachers [43]. It is imperative for the teachers to work significantly in the discipline of technology, but they should be trained to follow the ethical standards and guidelines which are required by them. By following the ethical standards, the teachers can use LLM in a fair way [44]. It would be useful for the teachers to improve their overall effectiveness.

Besides, the application of technology would be useful for the teachers to improve their learning and strategic performance which is significant based on teachers' behavior [45]. Although the teachers are trained to follow ethical principles while dealing with the students and other classroom activities, it is necessary for them to follow the significant directions of working which can improve the performance of students [46]. Therefore, a significant level of work for the application of LLM is required by the teachers and they should more focus on the ethics in it. In this way, it would be a significant improvement in the learning and performance of teachers that would be helpful in data driven decision making [47]. Hence, the ethical standards for use of LLM should be prioritized by the teachers. For this purpose, it is necessary to train the teachers for effective use of technology which can boost their performance [48]. The use of LLM based applications is also important for the students in the modern time, but they should be working effectively and no norms related to academic requirements should be violated [49]. Hence, it would be effective for the teachers to improve their performance in a better way [50]. Following the ethical standards, the fair use of technology is a significant approach to contribute to the knowledge and learning of students. Thus, the next hypotheses of the study are formulated as: there is a moderating impact of ethics in LLM use between

technological pedagogical knowledge for LLM application use and data driven decision making (H4); there is a moderating impact of ethics in LLM use between technological content knowledge for LLM application use and data driven decision making (H5); there is a moderating impact of ethics in LLM use between pedagogical content knowledge for LLM application use and data driven decision making (H6). The model of study is shown in Figure 1.

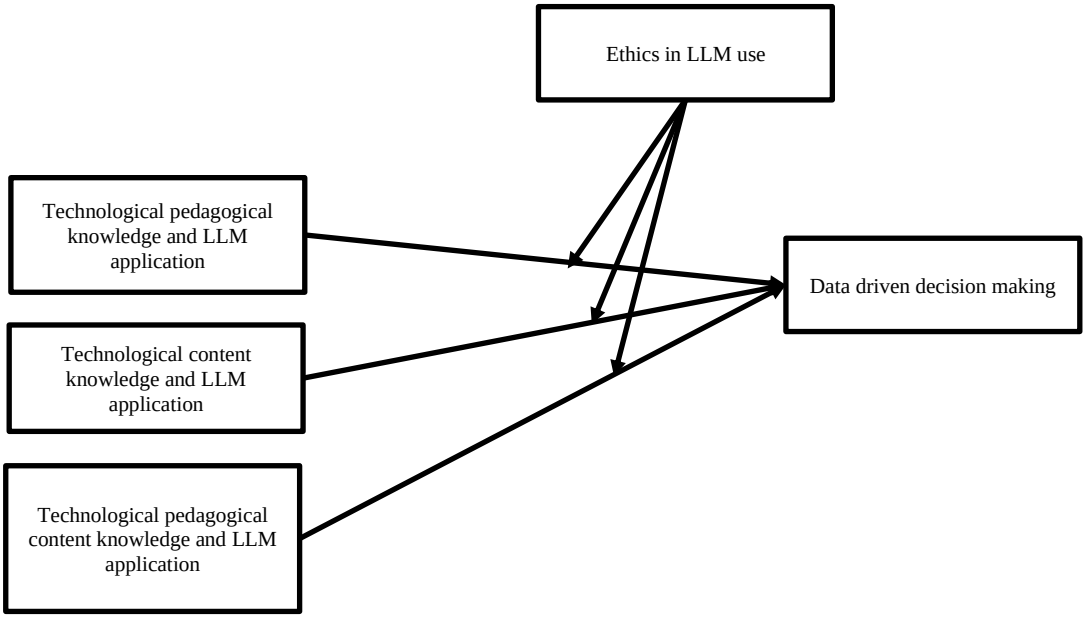

Figure 1. Research model

3. METHOD

This research used primary data to achieve its objective. The primary data collected was collected on the questionnaire. There were Likert scale instruments used in the questionnaire to collect the data. In this study, data driven decision making was tested how teachers use data from students monitoring system. Furthermore, technological pedagogical knowledge and LLM application was tested how technological and pedagogical knowledge for teachers for AI has an effect on their decision making. Similarly, technological content knowledge and LLM application was tested on how technological and content knowledge for teachers for AI has an effect on their decision making. On the other hand, technological pedagogical content knowledge and LLM application tested how technological, pedagogical and content knowledge for teachers for AI has an effect on their decision making. Finally, ethics in LLM use was tested how teachers know and follow the ethics of using AI.

These instruments were taken from the previous studies [47], [51] and reported in Table 1. Previous studies in literature also used and validated these instruments to reach the findings. Furthermore, this study collected quantitative data because it measures the variables based on the suggestions of prior studies. The population of this research were the teachers at universities located in Chengdu, Sichuan, China. The study used survey based methods to collect data as it is helpful to save the time and cost of the study. Furthermore, this study used a purposive sampling method to collect data. During purposive sampling, the teachers who were using LLM based AI in their teaching were selected for the collection of data.

According to Memon *et al.* [52], the sample of the study should be appropriate for generalization of the findings. Whereas Hair *et al.* [53] recommended that a sample of more than 300 responses is appropriate to reach at the findings. This study surveyed 400 questionnaires among the teachers to collect the data. However, 322 responses were collected back. The respondents were requested to provide significant data for this study as the findings were related to them. During the preliminary analysis, 3 responses were deleted as they were not fit for the findings of the study. Therefore, a sample of 319 respondents was finalized for the findings of this research. For the analysis of collected data, this research used Smart PLS 4. This software was used for the findings of partial least square–structural equation model (PLS-SEM). The study has used the findings of factor loadings, variance inflation factors (VIF), reliability, discriminant validity, path coefficients, effect size, and predictive relevance.

Table 1. Instruments

Variable	Items
Technological pedagogical knowledge and LLM application	I can understand the pedagogical contribution of AI-based tools to my teaching field.
	I can evaluate the effectiveness of feedback provided by AI-based tools in teaching and learning.
	I can select AI-based tools that help students apply their knowledge.
	I know how to use AI-based tools to monitor students' learning progress.
	I can interpret feedback messages from AI-based tools to provide real-time feedback to students.
	I can understand the alerts from AI-based tools to scaffold students' learning.
	I have the knowledge to select AI-based tools to motivate students in their learning.
Technological content knowledge and LLM application	I can use AI-based tools to search for educational material relevant to my teaching field.
	I am aware of various AI-based tools used in my professional field for teaching purposes.
	I can use AI-based tools to better understand the content of my teaching field.
	I know how to utilize field-specific AI-based tools in my teaching.
Technological pedagogical content knowledge and LLM application	In my teaching field, I know how to use different AI-based tools to provide personalized feedback to students.
	In my teaching field, I know how to use different AI-based tools to support personalized learning.
	In teaching my field, I know how to use different AI-based tools for real-time feedback.
	I can use AI-based tools with various teaching strategies to teach my subject effectively.
	I can effectively combine teaching content, AI-based tools, and teaching strategies in my lessons.
	I can take a leadership role among my colleagues in integrating AI-based tools into our teaching field.
	In my teaching process, I can select various AI-based tools to monitor students' learning progress.
Ethics in LLM use	I can assess to what extent AI-based tools consider individual differences among students.
	I can evaluate whether AI-based tools behave fairly towards all students.
	I can understand the reasoning behind any decision made by an AI-based tool.
	I can identify the responsible developers involved in the design and decisions of AI-based tools.
Data driven decision making	When setting learning goals for underperforming students, I use test data related to the subject.
	I use test data from the student monitoring system when setting learning objectives for my classes.
	I use assessment tests related to the course content to evaluate student progress.
	I use subject-related test data to adapt my instructions to meet student needs.
	I use data from the student monitoring system to provide additional (individual or group) instruction for underperforming students.
	I use relevant tests to develop teaching plans for students with different levels of performance.
	I determine which students require more frequent attention during or after a task based on test data.
	I use test data from the student monitoring system to improve my classes.
	I use assessment test results to provide students with feedback on their problem-solving strategies.
	I use calculus course tests when determining the pace at which I discuss the curriculum.
	I use data from the student monitoring system when determining the pace of curriculum discussion.
	I refer to test data when selecting specific skills or topics that need further explanation in class."

4. RESULTS AND DISCUSSION

The findings of demographic analysis were tested at the first stage. According to findings in Table 2, 41% of the teachers were teaching social sciences, 19% were teaching pure sciences, 30% were teaching mathematics while 10% were teaching other disciplines subjects. Among the respondents, 51% were male while 49% were females. Regarding experience, 9% employees had experience of less than three years, 54% had experience between 3–5 years whereas 37% had experience more than 5 years. Furthermore, 20% of the respondents reported that they used AI rarely but 80% discussed they used AI every day. Finally, 63% reported that they like to use AI, 27% remained neutral and 11% reported they do not like to use AI. These demographics information explained about the respondents.

According to Sarstedt *et al.* [54], the findings of factor loadings are used to determine the reliability of instruments. It is necessary to test the reliability and validity of each scale which is necessary for acceptance of them for data analysis. In measurement model assessment, factor loadings value above 0.70 are used to determine the scale is valid [54]. All scale items achieved a significant threshold of factor loadings, it is confirmed that all scales are used to determine the findings. Furthermore, the common method bias in the data was checked with the findings of VIF. It is tested because the same constructs and instruments are used to collect data. The findings of VIF below 3.3 are considered significant for no bias in data [54]. The study found that no value for each scale item was above 3.3 which confirmed that there was no variance in the data. The findings are reported in Table 3. The measurement model is illustrated in Figure 2.

Table 2. Demographics (n=319)

Variable	Level	Frequency	Proportion (%)
Subject teaching	Social sciences	131	41
	Pure sciences	62	19
	Mathematics	95	30
	Others	31	10
Gender	Male	162	51
	Female	157	49
Years of experience	Less than 3 years	30	9
	3–5 years	172	54
	More than 5 years	117	37
Frequency of LLM (AI) use	Rarely	64	20
	Almost everyday	255	80
Personal feelings about LLM (AI) use	I like to use it	200	63
	I am neutral about using it	85	27
	I don't like to use it	34	11

Table 3. Factor loadings and VIFs

Observed variables	DDDM	ELU	TCKLA	TPCKLA	TPKLA	VIF
DDDM_1	0.826					2.776
DDDM_2	0.806					2.575
DDDM_3	0.802					2.501
DDDM_4	0.816					2.638
DDDM_5	0.805					2.550
DDDM_6	0.851					3.143
DDDM_7	0.823					2.756
DDDM_8	0.836					2.898
DDDM_9	0.842					2.957
DDDM_10	0.819					2.666
DDDM_11	0.816					2.656
DDDM_12	0.800					2.450
ELU_1		0.850				2.066
ELU_2		0.815				2.050
ELU_3		0.869				2.216
ELU_4		0.831				1.893
TCKLA_1			0.847			2.043
TCKLA_2			0.816			1.884
TCKLA_3			0.840			1.991
TCKLA_4			0.833			1.995
TPCKLA_1				0.796		2.112
TPCKLA_2				0.819		2.256
TPCKLA_3				0.848		2.588
TPCKLA_4				0.831		2.387
TPCKLA_5				0.846		2.685
TPCKLA_6				0.796		2.338
TPCKLA_7				0.830		2.613
TPKLA_1					0.806	2.118
TPKLA_2					0.812	2.186
TPKLA_3					0.816	2.299
TPKLA_4					0.824	2.426
TPKLA_5					0.817	2.259
TPKLA_6					0.825	2.329
TPKLA_7					0.813	2.201

The findings of reliability and validity were tested to confirm the instruments are fit to analyze the data. The findings of Cronbach's alpha and composite reliability were tested. The findings of Cronbach's alpha and composite reliability above 0.70 are considered significant for analysis of data [54]. The study found that for all constructs, both thresholds were achieved. Therefore, the reliability and validity of the data was significantly achieved. The findings of average variance extracted were determined to test the variance in the data. The findings of the average variance extracted above 0.50 are accepted as significant [54]. Table 4 discussed that reliability and validity of the data was significantly achieved.

The findings of discriminant validity were tested at the next stage. This study used heterotrait-monotrait (HTMT) ratio was tested to measure the findings of discrimination. According to study by Henseler *et al.* [55], HTMT ratio should be less than 0.85 for significant acceptance no discriminant validity. The findings in Table 5 disclosed that there was no discrimination in the data.

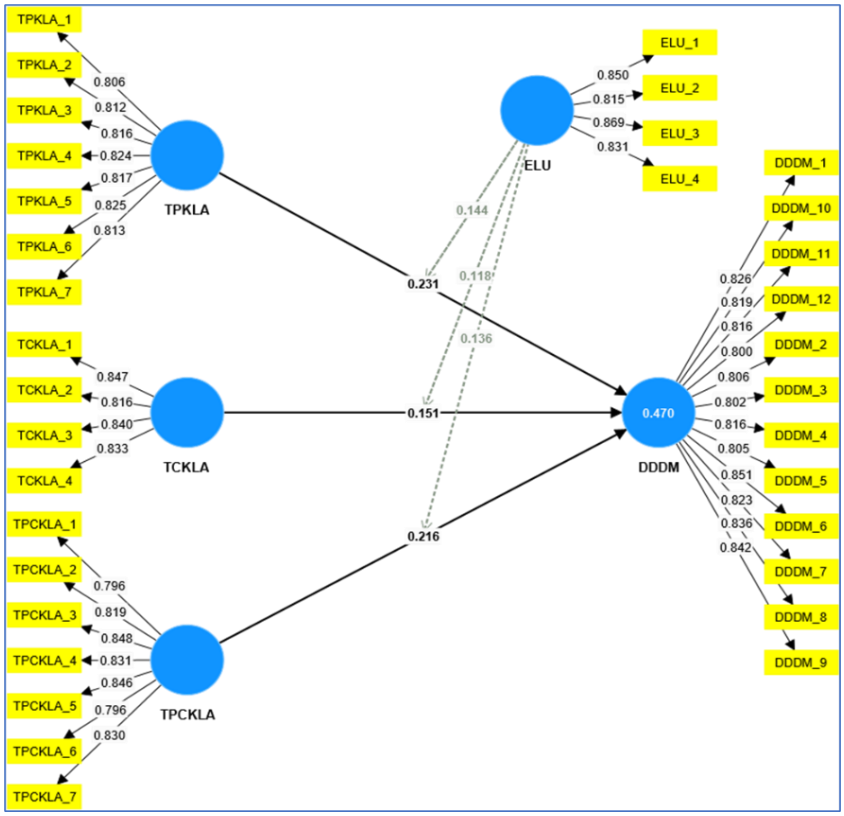

Figure 2. Measurement model assessment

Table 4. Reliability and validity

Construct	Cronbach's alpha	Composite reliability	Average variance extracted
DDDM	0.956	0.956	0.673
ELU	0.864	0.875	0.708
TCKLA	0.854	0.856	0.696
TPCKLA	0.921	0.925	0.679
TPKLA	0.916	0.917	0.666

Table 5. Discriminant validity

Construct	DDDM	ELU	TCKLA	TPCKLA	TPKLA
DDDM					
ELU	0.334				
TCKLA	0.513	0.453			
TPCKLA	0.518	0.309	0.430		
TPKLA	0.525	0.362	0.491	0.434	

The findings of path coefficients were tested to determine the relationships between variables. According to Sarstedt *et al.* [54], the p value less than 0.05 confirm the significant acceptance of a hypothesis. Discussing H1, it is found that there is a significant relationship between technological pedagogical knowledge for LLM application use and data driven decision making. Regarding H2, it is found that there is a significant relationship between technological content knowledge for LLM application use and data driven decision making. Discussing H3, it is found that there is a significant relationship between technological pedagogical content knowledge for LLM application use and data driven decision making. Testing H4, it is found that there is a significant moderating role of ethics in LLM use between technological pedagogical knowledge for LLM application use and data driven decision making. Regarding H5, it is found that there is a significant moderating role of ethics in LLM use between technological content knowledge for LLM application use and data driven decision making. Finally, testing H6, it is found that there is a significant moderating role of ethics in LLM use between pedagogical content knowledge for LLM application use and data driven decision making. The findings are reported in Table 6.

Furthermore, the findings of f square were tested to check the effect size. According to Cohen [56], effect size findings above 0.02 are small, above 0.15 is medium whereas above 0.35 is large. The study found that the effect of all three independent variables was small on dependent variables. The findings are also described in Table 6. The structural model is illustrated in Figure 3.

Table 6. Path coefficient and effect size

Paths	Original sample	Standard deviation	T statistics	P values	Effect size
TPKLA->DDDM	0.231	0.052	4.437	0.000	0.072
TCKLA->DDDM	0.151	0.053	2.848	0.004	0.029
TPCKLA->DDDM	0.216	0.051	4.246	0.000	0.065
ELU x TPKLA->DDDM	0.144	0.050	2.904	0.004	
ELU x TCKLA->DDDM	0.118	0.056	2.128	0.033	
ELU x TPCKLA->DDDM	0.136	0.054	2.502	0.012	

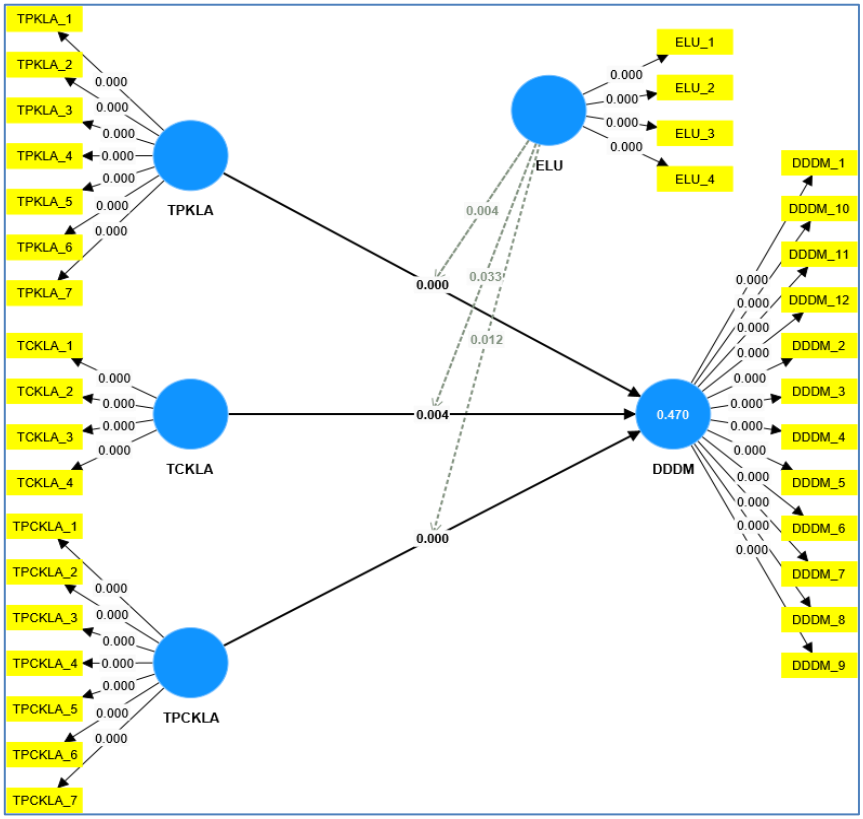

Figure 3. Structural model assessment

The findings of predictive relevance were tested to measure the predictive power of the model. According to Sarstedt *et al.* [54], the predictive relevance (Q2) should be above 0. In this study, the findings of Q2 are 0.320. Therefore, the study disclosed the model has 30% predictive power. The findings of predictive relevance are shown in Table 7 and Figure 4.

This research tested the hypotheses empirically based on statistical evidence. Discussing H1, it is found that there is a significant relationship between technological pedagogical knowledge for LLM application use and data driven decision making. The findings of this relationship were compared with the findings of existing studies. According to Fu *et al.* [41], it is important for teachers to make use of LLM in order to facilitate an improvement in their comprehension of the information pertaining to the students. LLM and other technologies based on AI are utilized in the classroom by teachers who are motivated to provide support for their students. While Chen *et al.* [49] discussed that the activities that instructors do within the classroom are planned with the help of LLM. This allows them to formulate the structure of teaching, the selection of content, and the way in which they anticipate the outcomes of their pupils.

Table 7. Predictive relevance

Construct	SSO	SSE	Q² (=1-SSE/SSO)
DDDM	3828	2671.582	0.302
ELU	1276	1276	0
TCKLA	1276	1276	0
TPCKLA	2233	2233	0
TPKLA	2233	2233	0

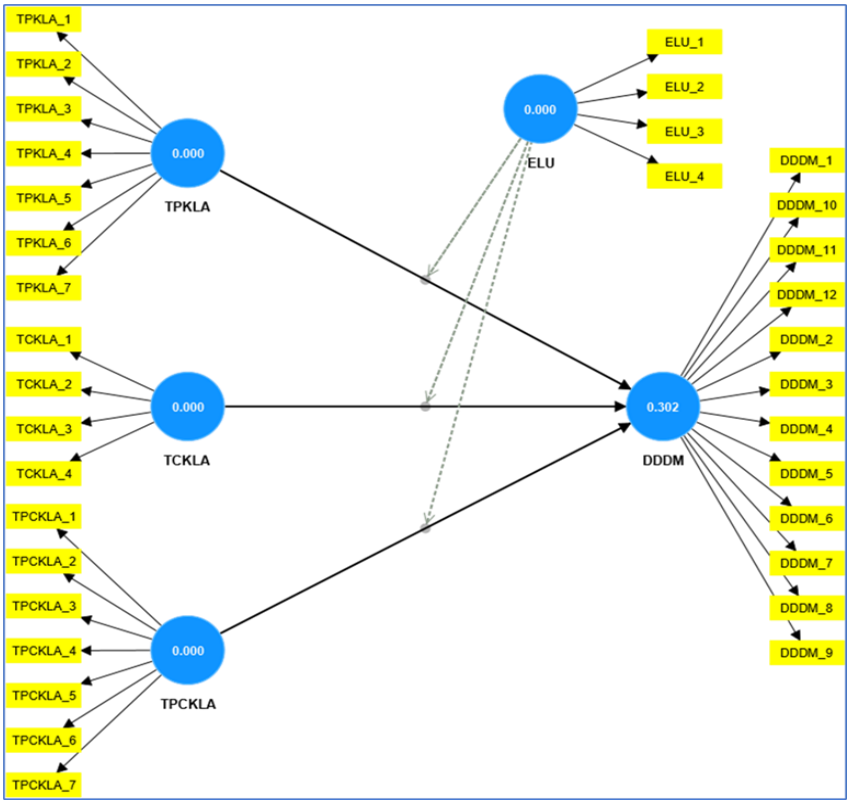

Figure 4. Predictive relevance

Furthermore, Nazari *et al.* [43] discussed that in order for teachers to cultivate a positive attitude towards their pupils, it is helpful for them to have knowledge about the process of curriculum development and the general teaching environment. According to Hwang *et al.* [50], students gain a better understanding of the dynamics of their learning and the decision-making process as a whole as a result of this. It is also recommended that teachers encourage their pupils to make use of technologies that are based on AI for the purpose of learning and participating in a variety of activities in the classroom. According to Yağcı [40], it has a positive effect on the kids' overall performance, which is steadily getting better. Moreover, teachers who are analyzing student data should make use of LLM in order to make decisions on the data collected from their pupils. Whereas Mandinach and Schildkamp [46] discussed that the data is properly analyzed and made available to the students, it effectively enhances their performance, which in turn helps them deal with substantial obstacles. However, in order to increase their performance, teachers need to be inspired to apply AI in an appropriate manner, which is important in today's current times.

Regarding H2, it is found that there is a significant relationship between technological content knowledge for LLM application use and data driven decision making. The findings of this relationship were compared with the findings of existing studies. The study by Sperling *et al.* [25] found that the instructors should have a solid understanding of the material covered in the class, as this has a direct impact on their students' learning and performance. The application of instructors' knowledge to the activities that take place in the classroom is facilitated by the utilization of technology that is based on LLM. Whereas Fu *et al.* [41] discussed that help with the preparation of the timetable as well as assistance with teaching methodology can be obtained through the utilization of LLM. According to Kim [31], to achieve this goal, it is vital to provide the teachers with training in order to urge them to make use of technology, which has an effect on their performance and improvement.

Moreover, the study by Tan [5] discussed that it helps with a variety of designs, the application of AI technology is also beneficial in terms of increasing the performance of teaching. The application of AI is also beneficial for educators, as it enables them to improve their teaching abilities by generating fresh ideas that are based on the characteristics of the students. On the other hand, Li and Su [44] discussed that the efficiency of the instructors' work and their ability to maintain their performance are both improved when they are able to make fair use of technology. Additionally, Yang *et al.* [27] discussed that the language-related modules are helpful in analyzing the data linked to the class, which assists the instructors in making decisions regarding the future consequences of the material for the course. To sum up, the content of the course is of important importance to progress its application for the purpose of improving the students' learning performance.

Discussing H3, it is found that there is a significant relationship between technological pedagogical content knowledge for LLM application use and data driven decision making. The findings of this relationship were compared with the findings of existing studies. According to Hemachandran *et al.* [32], it is essential for teachers to play a vital role in teaching knowledge, which includes imparting information about the subject matter, in order to enhance the students' overall performance and productivity. Furthermore, Su and Yang [45] discussed that in situations when teachers are highly driven, they are able to provide pupils with the support they need to effectively improve their performance. The use of AI is consequently enhanced with the assistance of educators and the performance of students. According to Bragg *et al.* [38], it is essential for the educators to work together to enhance their performance, as this has a substantial bearing on the decisions that they make. For the purpose of analyzing the information that pertains to the pupils, it is essential for the teachers to make use of LLM or other apps that are associated with technology.

On the other hand, Bragg *et al.* [38] also discussed that in terms of the academic success of the pupils, the instructors are extremely motivated to make use of instruments that are associated with AI. According to Lepp *et al.* [42], the utilization of tools that are associated with AI is helpful in organizing the data of pupils and evaluating their performance. Due to the fact that it has an effect on the decisions that instructors make, having a strong understanding of the subject matter is also essential for them to improve their learning. According to Chiu [37], the utilization of LLM provides students with the assistance they need to effectively improve their performance, which is essential for the teaching and learning of students. While Zhang [39] discussed that it is the responsibility of the teachers to make effective use of LLM, which makes the instructional methodologies that they employ more effective. To achieve this goal, the administration of higher education institutions ought to provide students with training that is both efficient and effective.

Testing H4, it is found that there is a significant moderating role of ethics in LLM use between technological pedagogical knowledge for LLM application use and data driven decision making. Regarding H5, it is found that there is a significant moderating role of ethics in LLM use between technological content knowledge for LLM application use and data driven decision making. Finally, testing H6, it is found that there is a significant moderating role of ethics in LLM use between pedagogical content knowledge for LLM application use and data driven decision making. The findings of this relationship were compared with the findings of existing studies. According to Hooda *et al.* [48], the application of technology that is based on AI ought to be founded on ethical standards, which are beneficial in educational institutions. On the other hand, Celik [47] discussed that it is essential for educators to receive adequate instruction on the ethical norms that should be followed when utilizing technology. Furthermore, there is a possibility that teachers will utilize the technology associated with generative LLM in a manner that is deceptive, which will not have any effect on the application that teachers will use.

In addition, the study by Lepp *et al.* [42] discussed that it is strongly suggested that the educators put in a large amount of effort to enhance the implementation of LLM. Similarly, there are instances when teachers have little awareness regarding the application of AI in academic disciplines, despite the fact that they have information about the content expertise to begin with. According to Gao *et al.* [28], it is advised that teachers increase their use of AI in this manner; however, they should adhere to all of the ethical criteria. Whereas Sperling *et al.* [25] found that an effective method of adhering to ethical standards in the implementation of technology would be a huge step forward for the educators. It is essential for educators to devote a large amount of their time and energy to the field of technology, they need also to receive training to ensure that they adhere to the ethical standards and norms that are required by them. According to study by Atif *et al.* [34], the lecturers are able to use LLM in a fair manner if they take the ethical criteria into consideration. The teachers would benefit from increasing their overall effectiveness, which would be beneficial.

According to Kim *et al.* [29], the implementation of technology would be beneficial for teachers, as it would help them improve their learning and strategic performance, both of which are significant depending on the behavior of teachers. Furthermore, Luo and Cheng [8] discussed that despite the fact that instructors are educated to adhere to ethical standards when interacting with students and participating in

other activities in the classroom, it is essential for them to adhere to the significant directions of working, which can lead to improvements in the academic performance of students. Whereas scholars also discussed that it is for this reason that teachers are required to put in a large amount of effort in order to implement LLM, and they should place a greater emphasis on the ethical implications of this. Study by Kumar *et al.* [26] discussed that there would be a huge improvement in the learning and performance of teachers as a result of this, which would be beneficial in making decisions based on evidence.

Moreover, the ethical criteria that pertain to the use of LLM ought to be given priority by the educators. To achieve this goal, it is essential to provide the educators with training on how to make good use of technology, which can improve their overall performance [40]. According to Kumar *et al.* [26], the usage of applications that are based on LLM is also crucial for students in the modern era, these applications should function efficiently, and there should be no violations of any standards that are relevant to the criteria for academic assignments. According to Bragg *et al.* [38], it would be beneficial for the teachers to improve their performance in a more effective manner. In accordance with the ethical norms, the equitable utilization of technology is a significant approach that can significantly add to the students' knowledge and abilities to learn.

5. CONCLUSION

To conclude, the study has both theoretical and practical implications. In theoretical implications, it contributes to literature on AI and pedagogical skills. Furthermore, it also recommends significant practices to improve the LLM use by teachers in data-driven decision making. The study extends the body of knowledge by reporting that technological pedagogical knowledge for LLM application is significant antecedent of data driven decision-making by the teachers. The previous studies paid less attention to this research. This study added to the discourse that technological pedagogical knowledge of the teachers is a significant factor which leads them to use LLM for analyzing the data and record of students to make a decision. The study also discussed that technological content knowledge of the teachers have a significant impact on their AI use. It is discussed that when the students have significant knowledge about the content of teaching, they are satisfied and confident to use AI for the purpose of decision making. However, they tend to use AI for the purpose of data analysis that helps to make decision making based on facts. Thirdly, the study discussed that technological pedagogical content knowledge for LLM use is also significant for data driven decision making by the students. The findings of this research in other ways denote that teachers should have access to both technological and content knowledge which helps them to use LLM (AI) properly to analyze the data of students.

Furthermore, the study contributes to knowledge that when the teachers have ethics to use LLM (AI), their pedagogical knowledge facilitates them to use AI properly for teaching and analyzing the data of the students in universities' databases. In this way, the teachers would be doing data analysis ethically and their decision would be based on accurate data. In addition, the study discussed that the interaction of ethical use of LLM and technological content knowledge has a significant impact on the data driven decision-making by the teachers in different universities in China. Therefore, it is recommended that the teachers should use AI ethically which is helpful to utilize their content knowledge which is significant for their data driven decision-making. Finally, the study contributes to the body of knowledge that teachers' technological pedagogical content knowledge has a significant internation with ethics in use of LLM and impact on the data driven decision making about the students. The findings of this research can be used by the teachers in China to improve the overall decision making process for the betterment of the students.

The findings of this research are used to test the hypothesis which are noteworthy contributions to literature. However, this study has some limitations that are required to be discussed further. To begin with, the study has limitation with the data as data was collected from a selective geography which cannot be a representation of all teachers in China. Therefore, the data collected from teachers at national level in Mainland Chian would have a significant impact on the findings. Therefore, future studies are required to collect data from a large sample despite any geographical selection. It would be an effective strategy to understand the findings in a broader context. Secondly, the study collected cross-sectional data which was collected at one period of time. Future studies are recommended to collect data using longitudinal design. It will affect the findings and understand to better interpret into the context of China. Thirdly, this study tested data driven decision-making with AI use, but it paid less attention to understanding the role of teachers' technology (AI) acceptance which makes this research limited to understand and interpret the findings. Therefore, future research is recommended to test the mediating role of technology acceptance which would be a significant contribution to literature.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
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P : **P**roject administration
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

Derived data supporting the findings of this study are available from the corresponding author [JZ] on request.

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