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Understanding deep learning across academic domains: A structural equation modelling approach with a partial least squares approach

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Abstract

This study investigates the impact of deep learning on various academic disciplines including arts and humanities, social sciences, engineering, health and management to explore its implications on academic achievement, research and societal relevance. This study shows that deep learning impacts social sciences, engineering, health, the arts, the humanities and management disciplines. Deep learning combines artificial intelligence and machine learning revolutionizing the teaching and learning experience. This research carefully explores the implications of deep learning on academic achievement, research and societal relevance, hence filling gaps in understanding deep learning in diverse academic domains. The quantitative research approach collects data from top-ranked global university students producing 971 valid responses from different academic disciplines. SEM and CFA were employed to validate the measurement model, thereby providing a robust statistical foundation for the study. This study illustrates that diverse academic domains have strong and positive relationships between deep learning, academic influence, research enhancement and social relevance. However, the observation of deep learning has a greater impact on the field of science and technology. The findings of this study emphasize ethical frameworks, model interpretability and responsible resource allocation in deep learning integration. This research guides teachers, policymakers and institutions to maximize the benefits of deep learning in diverse academic fields by emphasizing ethical considerations, interdisciplinary collaboration and long-term planning for responsible and effective integration.

Keywords: Academic impact of deep learning, Artificial intelligence in education, Deep learning, Digital education transformation, Educational technology, Technology integration in academic research.

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1. Introduction

The integration of deep learning technologies has transformed the educational landscape in the last several decades [1, 2]. Deep learning is an integration of artificial intelligence (AI) and machine learning (ML) that has emerged as a powerful tool to influence the direction of research, academics and society [3, 4]. Deep learning analytics are used to analyze vast datasets, illustrate complex patterns and generate insights that conventional methods fail to calculate [5]. Integrating deep learning in academics promotes innovation in teaching and learning by providing an adaptive method of learning experiences [6], a personalized learning approach and new educational shifts in different fields such as arts and humanities, social sciences, management, science and technology and medical and allied studies. This paradigm shift has improved the learning process by providing students with essential learning skills that are necessary for the current employment market. Deep learning also has societal implications in different fields that extend from healthcare diagnostics to predictive modeling [7], natural language processing [8] and recommendation systems [9]. Deep learning automates complex tasks using AI and ML to enhance and optimize resources addressing significant social concerns. The application of deep learning transforms academic research and positively affects society [10]. Several institutions have transformed their academic systems and integrated AI and ML into their curricula [11]. Hence, ML and AI have been inculcated as integral parts of academia in the current academic paradigm [12-14]. In the context of recent developments in academia and changes in the employment structure in the market, the conventional teaching methodology faces challenges in levering the digital education system and innovation to develop and engage students more in academics and research [15].

There is a significant research gap in the context of deep learning across diverse academic domains although the online education system has witnessed exponential growth. Their research gap also existed about the level of adoption and its significant impact in different academic domains. Previous research has emphasized the achievements of online education and the significance of AI and ML. Previous studies also lack a comparative study in the context of deep learning across different domains of academia. Moreover, there exists a potential gap in context for the comparison among students' emotions and engagement components. This gap pertains to the comprehension of students' emotional and involvement components during online classes.

The primary objective of this research is to thoroughly examine the impact of deep learning on diverse academic disciplines such as arts and humanities, social sciences, engineering, health and management studies. The study aims to investigate the impact of deep learning on academic achievements, advanced research endeavors and societal importance across several disciplines. This research aims to assess the reliability and accuracy of deep learning concepts by using measurement models such as Cronbach's alpha, composite reliability and discriminant validity. In addition, this study uses the Partial Least Squares (PLS) method to examine the structural equation model (SEM) presenting a visual representation of the variables and explaining how these factors influence academic and societal results. This research seeks to provide valuable insights into the relationship between deep learning and its implications in various academic fields. By providing a graphical representation of the relationships between variables and offering insights into how these factors contribute to academic and societal outcomes. This will contribute to a better understanding of the role of deep learning in education, research and society. The present research provides a detailed understanding of the intricate relationship between deep learning and its consequences in each particular sector through the analysis of theories from several academic disciplines. The study intends to contribute to a deeper understanding of the revolutionary potential of this technology in education and beyond through an in-depth investigation of the impact of deep learning on academic achievement, research advancement and societal relevance.

The significance of the present research lies in the extent to which deep learning could be used in different academic fields. The research can open avenues by which deep learning could be comprehended and how it could be implemented to improve students' engagement in different academic domains. The study provides an in-depth study and wider discussion on the impact of technology in education by providing a valuable study. It adds to the wider discussion on the impact of technology in education, providing valuable perspectives on AL and ML. The study's implication could transform teaching methodology to the next level of paradigm. In the context of the recent transformation towards digital education, this study highlights useful information that can help teachers and policymakers shape the academic landscape by emphasizing deep learning.

2. Literature Review

2.1. Stream-Specific Academic Impact

Deep learning has changed the standard of academics in the last several years. The method uses advanced content analysis algorithms to speed up the book review process [16]. The approach makes the study more efficient and helps learners understand the historical, cultural and literary context better. Studies in the past have shown that using Natural Language Processing (NLP) techniques has a significant effect on how students communicate with each other in academic institutions. Deep learning is essential in the visual arts classroom because it helps students find their unique ways of observing things and get a better understanding of how to be creative [17]. Criticism based on questions about model comprehension draws attention to the necessity of transparency in ensuring the accuracy of academic impact. Deep learning makes a significant difference in how well students perform in institutions in the areas of business and social sciences. Students use methods for data analysis to carefully look into big datasets. This lets them come to smart conclusions, use predictive modeling and do sentiment analysis [8, 18]. This makes it easier to understand data and social trends which give managers useful strategic information and the power to make decisions. However, several studies have shown that ethics concerns and criticisms about data privacy are big problems that force scientists and researchers to use responsible methods [19, 20].Deep learning provides science and engineering students with effective methods to analyze data, identify patterns and develop intricate models. It is important for scientific study and drives many fields, including genetics, materials science and environmental research [21]. It keeps students updated on technology progress. Deep learning is widely used even though it's hard to do calculations and making smart decisions takes a lot of time and money. Deep learning transforms the methods of study and evaluation in both paramedical and medical education through its use in medical image analysis, disease prediction and medicine discovery. Students get better at diagnosing and treating illnesses by better understanding complicated medical information [22]. Even though this new technology has had a huge effect, there are concerns about how it can be interpreted. This shows how important it is for the healthcare field to have reliable and understandable models [23]. Deep learning is being used a lot in scholarly fields which has led to different opinions and criticisms [24]. These include problems with understanding, resource use and moral issues. It is very important to solve these issues before deep learning can be widely used in academic studies [25]. Based on the review, the following hypotheses are proposed:

H_1 (AH): Deep learning has a significant impact on an academic in the domain of the arts and humanities.

H_1 (SSM): Deep learning has a significant impact on an academic in the domain of Social Science and Management (SSM).

H_1 (SE): Deep learning has a significant impact on an academic in the domain of Science and Engineering (SE).

H_1 (MAS): Deep learning has a significant impact on an academic in the domain of Medical and Applied Science (MAS).

2.2. Stream-Specific Skills and Research Enhancement

Research and Development (R&D) is a systematic and creative process that increases knowledge and creates new applications by comprising researching, designing and testing innovative goods, services and processes to boost innovation and competitiveness. Students' studies and skills get better when they learn more about the arts and sciences. Automatic data analysis lets students learn from big sets of data and get better at analyzing them [26]. Pattern recognition is a part of deep learning that helps find details in language, artistic movements and subject matter in both written and visual data [27]. Technology promotes both creative and critical thinking since it allows people to review and create new ideas. Students' skills improve when they do an interesting cross-disciplinary study through deep learning which lets them be creative and do their research. It is not possible to make the expected contributions because the models are not easy to understand which is important in fields that depend on being able to read and analyze data. Deep learning helps students in the social sciences and management do better research with automatic reviews and a focus on data [28]. Interpreting data helps us understand things that happen in business, society and the economy. Predictive modeling makes predictions more accurate while mood analysis helps students understand the market better [27, 29]. Decision-support systems help students plan and figure out how to solve problems [30,31]. Deep learning simplifies the study of data for science and engineering students which helps them learn important skills and do better research [32]. This lets students focus on making interpretations and hypotheses which helps them get better at problem-solving and analyzing [33]. Deep learning in sound and picture processing helps students understand what they see and hear. Everyone should be able to improve their skills but a lack of resources makes this hard to do [34]. Deep learning makes study and skills better in medical and paramedical education. By automating the analysis of medical images, students can focus on making practical decisions and taking care of patients. The technology ability to spot trends in medical data makes analysis and data-driven healthcare better [35]. Deep learning apps in tailored medicine, genetics and statistics can help students learn more about medical science [36]. The case for healthcare skill development stresses how important it is to have models that are both technologically advanced and easy to understand when making important decisions [37, 38]. When deep learning is used to improve skills, implementation, criticism, debate and resistance must be handled. Each academic field needs to deal with its own set of problems in order to encourage responsible and successful adoption [39]. The following hypotheses are proposed from the above review:

H_2 (AH): Deep learning has a significant impact on research enhancement in the domain of the arts and humanities (AH).

H_2 (SSM): Deep learning has a significant impact on research enhancement in the domain of Social Science and Management (SSM).

H_2 (SE): Deep learning has a significant impact on research enhancement in the domain of Science and Engineering (SE).

H_2 (MAS): Deep learning has a significant impact on research enhancement in the domain of Medical and Applied Science (MAS).

2.3. Stream-Specific Social Relevance

When deep learning is added to the arts and studies, it makes them more important to society by encouraging new ways of telling stories and making art. Deep learning is used by researchers to make video projects that keep a lot of students interested [40]. Deep learning lets us look at social problems more completely by looking into historical and cultural setting and using its pattern recognition abilities [41]. Individualized learning systems which are powered by deep learning adapt to each student's needs. This makes sure that educational material is always useful and accessible. Students improve their ability to deal with modern social and cultural problems by learning how to use these tools well [42]. This connects their studies to bigger issues in society. There are different points of view, complaints, disputes and obstacles in many areas where deep learning is used. Interpretability and openness are emphasized as very important in the analysis with a focus on models that are easy to understand and boost trust in society.

Deep learning makes a big difference in the social impact of social science and management studies by handling current issues and encouraging students to make smart decisions [43]. Mood analysis apps help make sure that tactics are in line with what people want by showing how people feel. Using ethical standards encourages making reasonable decisions and includes everyone. Deep learning's ability to handle huge amounts of social data makes it easier for researchers to learn about problems in society. Students are better prepared to deal with the complicated workings of society and business by using deep learning principles in their schoolwork. This makes sure that their projects are relevant and have an effect [44]. This argument says it is very important to use deep learning and technology properly; keeping ethics concerns in mind to make sure they have positive effects on society.

Deep learning has become more important to society by solving several important problems and encouraging new ideas in science and technology. Teachers can see how technology has changed things by looking at how it is used in healthcare, climate studies and environmental tracking through predictive modeling [45, 46]. When experts in these areas figure out hard problems, they make big advances [47-49]. When experts from various disciplines collaborate using deep learning applications, a more comprehensive strategy for resolving global issues is developed. Teachers can give students the skills they need to solve important problems in society by adding deep learning to the curriculum. The problem of not having enough resources needs to be fixed because it causes problems and could have negative effects on society.

The medical and paramedical sectors use deep learning to enhance healthcare results and tackle global health concerns through the use of applications such as predictive diagnostics and telemedicine. More people will have access to high-quality medical care. Deep learners also fight for healthcare solutions that are equal for all in addition to being students actively involved in deep learning. Students will be better prepared to face the problems of modern medicine if it is a part of medical school [49]. Therefore, they can greatly aid in the improvement of healthcare and the general welfare of society. Concerns about the reliability, interpretability and societal consequences of deep learning models in healthcare have been raised. A complex process including implementation, review, conversation and dispute is required to successfully integrate deep learning into many fields to improve society. Thorough consideration of ethics, transparency and resources is required to attain societally beneficial outcomes. Different barriers necessitate different solutions in every stream. Hence, the following hypotheses are proposed:

H_3 (AH): Deep learning has a significant impact on social relevance in the domain of arts and humanities (AH).

H_3 (SSM): Deep learning has a significant impact on social relevance in the domain of Social Science and Management (SSM).

H_3 (SE): Deep learning has a significant impact on social relevance in the domain of Science and Engineering (SE).

H_3 (MAS): Deep learning has a significant impact on social relevance in the domain of Medical and Applied Science (MAS).

After subsequently examining the previous literature, it is apparent that although online education has seen a substantial increase, there is still a substantial lack of study on the use of deep learning in diverse academic fields. This gap pertains to comprehending the extent of adoption and its substantial influence across these diverse fields. Existing research has highlighted the successes of online education and the significance of AI and ML. However, there is a lack of comparative studies that investigate the impact of deep learning in various academic disciplines. Moreover, there is a further discrepancy in the assessment of students' emotions and degrees of participation in different educational settings, specifically in online courses. It is crucial to address these gaps to gain a thorough understanding of the consequences of deep learning in education on student outcomes and experiences. Hence, the following framework for the study has been shown in Figure 1.

2.4. Framework of Study

Figure 1 illustrates the graphical representation of the conceptual framework of the study. The study investigates how deep learning affects academic influence, research enhancement and social relevance.

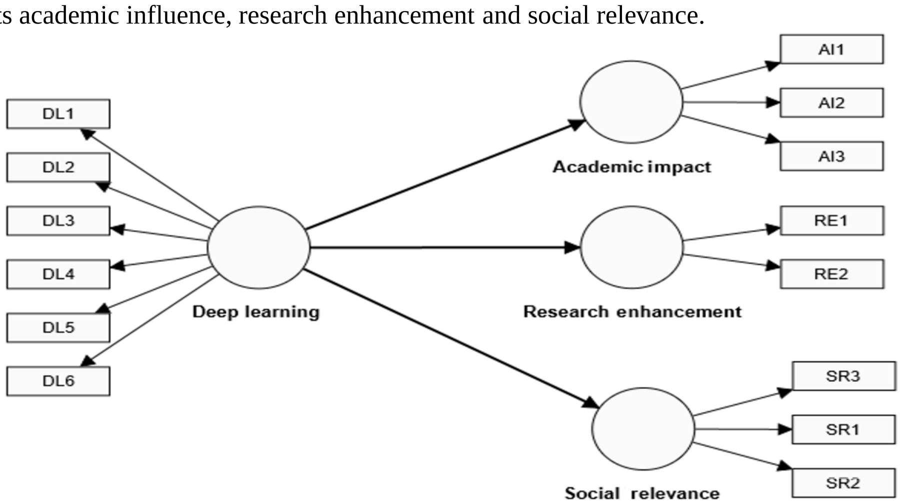

Figure 1.
Framework of the study.

Quantitative data is collected from students at major global universities in various academic fields. Validating the measurement model with SEM and CFA ensures a solid statistical foundation. Deep learning affects academic influence, research enhancement and social relevance directly. The model calculates R-square and F-square to assess deep learning's explanatory power and effect size on these outcomes. In various academic contexts, this comprehensive approach analyzes how deep learning technologies can improve education, research productivity and society.

3. Research Methodology

3.1. Research Design

The principal objective of this research was to examine the efficacy of deep learning across various domains. This quantitative study employed a questionnaire as the principal data acquisition instrument (see Appendix 2). The survey was constructed by modifying well-established questionnaires found in the literature. A preliminary pilot test was undertaken to ascertain the questionnaire's validity before the main study.

3.2. Research Population

The sampling technique used in this study integrates aspects of purposive sampling and stratified sampling. Initially, the research focused on students who were currently attending universities that were ranked among the top 500 internationally based on their ranking in 2023. The deliberate selection was made to align with a purposive sampling method. The selection criterion was designed to guarantee a sample of students who have demonstrated exceptional academic performance and possess a wide range of unique experiences. Additionally, the researchers subdivided the chosen group into strata depending on academic areas including arts and humanities, social sciences, engineering, health and management studies. The gap facilitated the use of a stratified sample methodology guaranteeing the inclusion of participants from diverse academic disciplines. The research attempted to capture a wide range of opinions and experiences across several academic fields by stratifying the sample. The chosen sample technique aims to effectively achieve the research objectives by striking a balance between targeting specific groups and ensuring diversity and representation across academic disciplines.

The study sample comprised students enrolled in universities ranked among the top 500 worldwide as determined by the Times Higher Education ranking. We have used Structural Equation Modelling (SEM) and Confirmatory Factor Analysis (CFA) to validate measurement models and ensure the reliability and validity of our research findings. SEM allows simultaneous estimation of numerous variables and their interrelationships revealing the intricate mechanisms by which deep learning affects academic achievement, research development and societal relevance across disciplines. CFA evaluates measuring instruments' convergent and discriminant validity to corroborate our hypothesized model's structure, boosting our study's credibility and trustworthiness. In diverse academic settings, SEM and CFA provide a solid statistical foundation for extensive study and accurate interpretation of deep learning and its effects [50].

The sample size for this research was determined using SEM which multiplies the total number of responses by 10. Therefore, it is recommended to have a maximum sample size of 1000 students. 30 responses would be deemed insufficient for the selection process as per the rule. A purposive sampling method was implemented to ensure that the number of students from each academic discipline arts and humanities, social science and management, science and engineering and medical & paramedical studies was balanced. The questionnaire administration ensured that an equitable distribution of responses was obtained across all domains. In total, 971 valid responses were considered for data analysis.

A link to a Google Forms survey was distributed to one thousand students who had completed the initial year of their academic program. The questionnaire distribution was designed to ensure that each domain received a minimum of 500 responses. However, the total number of questionnaires received was 971 resulting in a satisfactory return rate of 97.1% for this study. The survey topics were derived from those that had been published in prior research. The survey item was evaluated using a five-point Likert scale where responses ranged from five (indicating strong agreement) to one (indicating strong disagreement) regarding respondents' perceptions of the benefits of deep learning in their specific field of study.

3.3. Research Instruments

The questionnaire was developed by adapting prior surveys from existing literature. The report comprised multiple sections encompassing demographic data, evaluations of online platforms challenges faced in online education, successful methods to improve student involvement, and open-ended questions about further issues and strategies particular to online learning. The survey item was assessed using a five-point Likert scale to measure respondents' perceptions regarding the advantages of deep learning in their particular area of study.

3.4. Test for Robustness of the Study

We used a thorough series of tests to evaluate the validity and consistency of our measurement models to ensure the strength and accuracy of our research findings. Convergent validity was assessed to determine the degree to which different measures of the same concept come together. We evaluated the reliability and validity of the measurement devices used in this study to verify their consistency and accuracy. The Heterotrait-Monotrait (HTMT) ratio and the Fornell-Larcker criterion were employed to assess discriminant validity. These methods help evaluate the extent to which certain constructs are separate and distinct from each other. In addition, we performed statistical tests such as F-square, R-square and R-square adjusted to assess the adequacy of fit for our structural equation models. In addition, we assessed the accuracy and precision of our model's estimations by evaluating predictive performance indicators such as Q^2predict, RMSE and MAE. The importance-performance map offered valuable insights into the relative significance and effectiveness of deep learning constructs in different academic fields, assisting stakeholders in prioritizing their efforts for the best possible results. Collectively, these tests and analyses enhanced the strength and accuracy of our research findings guaranteeing the credibility and dependability of our study.

4. Data Analysis and Interpretation

We employed measurement models and structural models in our research to thoroughly examine the correlation between deep learning components and their influence across various academic areas. The measurement approach facilitated the evaluation of the validity and reliability of the variables being investigated guaranteeing that our data precisely represented the fundamental constructions. We used methods such as Confirmatory Factor Analysis (CFA) and evaluated both convergent and discriminant validity to confirm the reliability of our measurement tools. Using the structural model, we were able to examine the intricate connections between these factors and investigate how they impact academic success, research progress and social importance. By employing Structural Equation Modeling (SEM), we successfully visually illustrated the connections between variables offering a thorough comprehension of the underlying mechanisms that influence the reported results. Hence, the combination of measurement and structural models offered a robust methodological foundation for our study enabling us to confidently and rigorously investigate the impact of deep learning in academia.

4.1. Measurement Model

Figure 2 illustrates the measurement model which is a very important statistical method to assess the robustness of the study. Finding the factor loadings is a simple and direct way to see how well the measures match up with the basic parts. Validity and dependability are the two most important parts of a measurement model that should be observed to assess how good it is. A few examples of these metrics include composite reliability, Cronbach's alpha and average variance extracted (AVE). Having a solid measuring technique to back up empirical research gives it legitimacy and rigor. It also provides a foundation for subsequent studies [51].

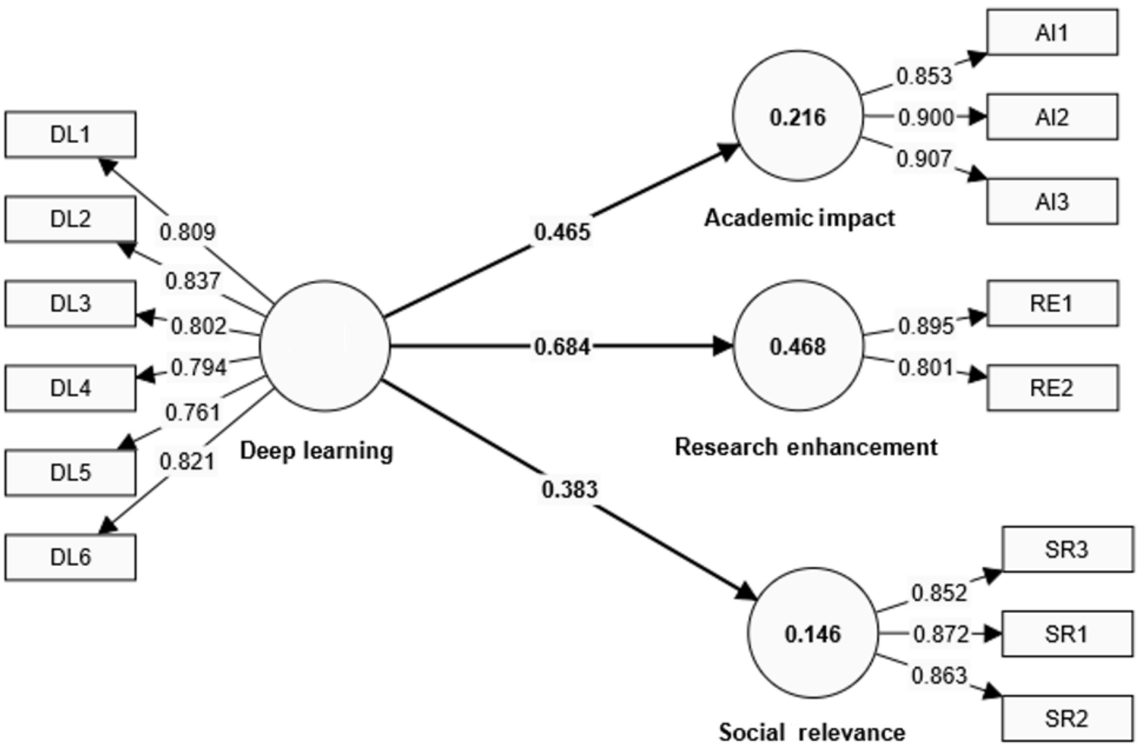

Figure 2.
Measurement model.

Table 1.
Construct reliability and validity.

Constructs	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Academic impact	0.865	0.877	0.917	0.786
Deep learning	0.891	0.895	0.917	0.647
Research enhancement	0.621	0.657	0.838	0.722
Social relevance	0.828	0.833	0.897	0.744

Ratings of the constructs' validity and reliability are shown in Table 1.These ratings provide important information on the correctness and usefulness of the measuring technique. High levels of reliability and internal consistency which are measured by Cronbach's alpha (0.865) and composite reliability (rho_a = 0.877, rho_c = 0.917) are essential for academic efficiency. High results on these two metrics show how reliable the composite is. Since the underlying idea accounts for a substantial portion of the measurement variation (as shown by the AVE score of 0.786) considerable convergent validity is evident. Their relationship is close. The concept of deep learning is reliable and has modest convergent validity (AVE = 0.647) with Cronbach's alpha = 0.891, rho_a = 0.895 and rho_c = 0.917. The research enhancement construct is very reliable with a Cronbach's alpha of 0.621, a rho_a of 0.657, and a rho_c of 0.838. They are quite satisfactory. Similarly, there is a high degree of convergent validity as shown by the AVE score of 0.722. Social relevance shows good reliability and convergent validity across numerous scenarios with a Cronbach's alpha of 0.828, rho_a of 0.833, rho_c of 0.897, and an AVE score of 0.744. By bringing all of this information together, we can see how trustworthy the measurement model is and we can provide a strong groundwork for future studies in structural equation modeling.

Table 2.
Discriminant validity (HTMT).

Constructs	Academic impact	Deep learning	Research enhancement
Academic impact	-	-	-
Deep learning	0.523		
Research enhancement	0.596	0.894	
Social relevance	0.724	0.443	0.514

Table 3.
Discriminant validity (Fornell Larcker criterion).

Constructs	Academic impact	Deep learning	Research enhancement	Social relevance
Academic impact	0.892			
Deep learning	0.339	0.761		
Research enhancement	0.308	0.663	0.858	
Social relevance	0.446	0.496	0.420	0.852

Table 2 shows the Heterotrait-Monotrait ratio often known as the HTMT ratio. With this ratio, we can see how unique each part is. To get the HTMT values, we look at the relationships between different constructs as well as the correlations within a single construct which are also called monotrait correlations. Deep learning's HTMT rating of 0.523 and research enhancement's HTMT rating of 0.596 are both lower than the generally acknowledged cutoff of 0.85. Both methods have sufficient discriminant validity in terms of their effect on academic performance as shown by these results. Both the research enhancement (0.894) and academic impact (0.523) assessments for deep learning HTMT are lower than the threshold. Both deep learning (HTMT score of 0.894) and research enhancement with academic impact (HTMT score of 0.596) fulfil or surpass the criteria indicating the existence of high discriminant validity. The results show that the parts have a high level of discriminant validity because the correlations between them are lower than the correlations between each idea and itself. As illustrated in Table 3, by the Fornell-Larcker criterion, the discriminant validity of the variable is validated. We can observe that each latent variable (academic impact, deep learning, research enhancement and social relevance) represents a strong positive correlation among themselves. Comparing the squared correlations with the Average Variance Extracted (AVE) for each variable illustrates that discriminant validity is achieved. If the squared AVE for each latent variable is greater than the correlations with other variables then the results suggest that these variables are distinct from each other in the measurement model. Hence, the derived results are highly reliable strengthening the robustness of the study.

Table 4.
F-square, R-square, and R-square adjusted.

F-square	Academic impact	Research enhancement	Social relevance	R-square	R-square adjusted
Academic impact	-	-	-	0.216	0.213
Deep learning	0.275	0.881	0.171	-	-
Research enhancement	-	-	-	0.468	0.466
Social relevance	-	-	-	0.146	0.143

In Table 4, the F-square statistics show that deep learning improves academic impact (0.275), research enhancement (0.881), and societal relevance (0.171). Deep learning enhances research, moderates academic significance, and limits social relevance according to these values. The model's variance explanation for each dependent variable is shown by R-square values. The academic impact R-square is 0.216 indicating that the model explains 21.6% of the variation. Deep learning strongly influences research enhancement as the R-square is 0.468 indicating that the model accounts for 46.8% of the variance. R-square = 0.146 implying the model explains 14.6% of social relevance's variance. Adjusted R-square values which account for model predictors are slightly lower but follow the same trend. Academic impact has 0.213 adjusted R-square, research enhancement has 0.466 and societal relevance has 0.143. These values illustrate the model's robustness and show that deep learning improves academic outcomes particularly research. According to the findings, deep learning strengthens research, academic performance and societal relevance. The results show that deep learning technologies in academia promote innovation, improve education and meet social requirements.

4.1.1. LV Prediction Summary

The LV prediction summary presents the latent variable performance within the framework of Structural Equation Modeling. The dataset comprises the anticipated values for every latent variable which are assessed for precision using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) metrics. Furthermore, the method incorporates cross-validation outcomes and statistics on model fit which are used to evaluate the generalizability and overall performance of the approach. The aforementioned instrument is of great significance in comprehending the predictive capacities of the latent variable model [52].

Table 5.
LV prediction summary overview.

Constructs	Q^2predict	RMSE	MAE
Academic impact	0.111	0.945	0.685
Research enhancement	0.437	0.752	0.533
Social relevance	0.242	0.873	0.617

According to Table 5, the predictive performance metrics [53] namely Q^2predict, RMSE and MAE provide significant insights regarding the accuracy of the model's outcome forecasts concerning social relevance, research enhancement and academic impact. The range of Q^2 predicts values between 0.111 and 0.437 signify a predictive capability that is moderate to substantial. As the value of Q^2 predicts increases, it indicates a more robust ability to account for variability in the endogenous constructs. The RMSE and MAE metrics which exhibit respective ranges of 0.533 to 0.685 and 0.752 to 0.945 underscore the model's accuracy in forecasting outcomes. Reduced values indicate enhanced precision, thereby validating the dependability of the model. In a nutshell, the aforementioned metrics collectively indicate that the structural model possesses satisfactory predictive capabilities. This establishes a reliable foundation for predicting outcomes within the designated academic disciplines and inspires confidence in its practicality.

4.2. Structural Model

The structural model is used to visualize the construction of a Structural Equation Model (SEM). The method is used to acquire knowledge by observing the integration of the primary components that are used as the base model for the study. The structural model enables us to establish dependable hypothesis-testing relationships among theoretical constructs and their observed indicators as well as among the theoretical constructs themselves. Moreover, it also enables the concurrent use of multiple indicator variables as per the construct. Path factors provide insight into the magnitude and direction of this occurrence. The present approach can be employed by academics to validate concepts and ensure that the structure is systematically organized [54].

4.3. Importance-Performance Map

The importance-performance map provides a detailed analysis of deep learning elements in academia as shown in Table 5A.

Table 5A
The importance-performance map.

Items	Importance	MV performance
Academic impact		
DL1	0.074	45.849
DL2	0.073	48.317
DL3	0.076	45.434
DL4	0.069	42.260
DL5	0.073	46.366
DL6	0.079	45.879
Research enhancement		
DL1	0.145	45.849
DL2	0.142	48.317
DL3	0.149	45.434
DL4	0.135	42.260
DL5	0.143	46.366
DL6	0.155	45.879
Social relevance		
DL1	0.109	45.849
DL2	0.106	48.317
DL3	0.112	45.434
DL4	0.101	42.260
DL5	0.107	46.366
DL6	0.116	45.879

This map shows the relative relevance of our research framework constructs. Each concept is given a weight or relevance score to indicate its impact on deep learning across academia. Strategic visualization helps discover important drivers and influential factors that affect academic achievement. The importance-performance map helps teachers, politicians and institutions concentrate on and invest in our study's most important constructs by showing their relative importance. This prioritization aligns academic tactics with the most important elements for favorable outcomes in the researched disciplines, targeting and maximizing deep learning's benefits. Thus, the importance-performance map helps stakeholders make educated decisions for deep learning integration in academic settings [55].

The importance-performance map shown in Table 5 illustrates the relationship between deep learning constructs (DL1 to DL6) and their weights in academic impact, research enhancement and social significance in our research. Academic impact gives DL6 the highest importance score (0.079) indicating its significant impact on academic results. Though DL2 and DL5 have lower significance scores, they do well with 48.317 and 46.366, respectively indicating strong academic influence. DL6 again ranks well (0.155) and performs well (45.879) in research enhancement. This shows that DL6 is important and effective in research advancement. DL2 and DL5 also have high-performance scores highlighting their research contributions. DL6 is significant for social relevance (0.116) matching its relevance in academic influence and research advancement. Despite being less important, DL2 and DL5 have good performance scores (48.317 and 46.366, respectively) demonstrating their social relevance. Overall, DL6 is crucial to academic impact, research enhancement and social relevance. DL2 and DL5 also perform well, bolstering their positive impact on our research. These importance-performance map insights might help stakeholders prioritize and optimize their efforts to integrate deep learning in academic settings as shown in Figures 3, 4, 5 and in Appendix 1 Confirmatory tetrad analysis (CTA).

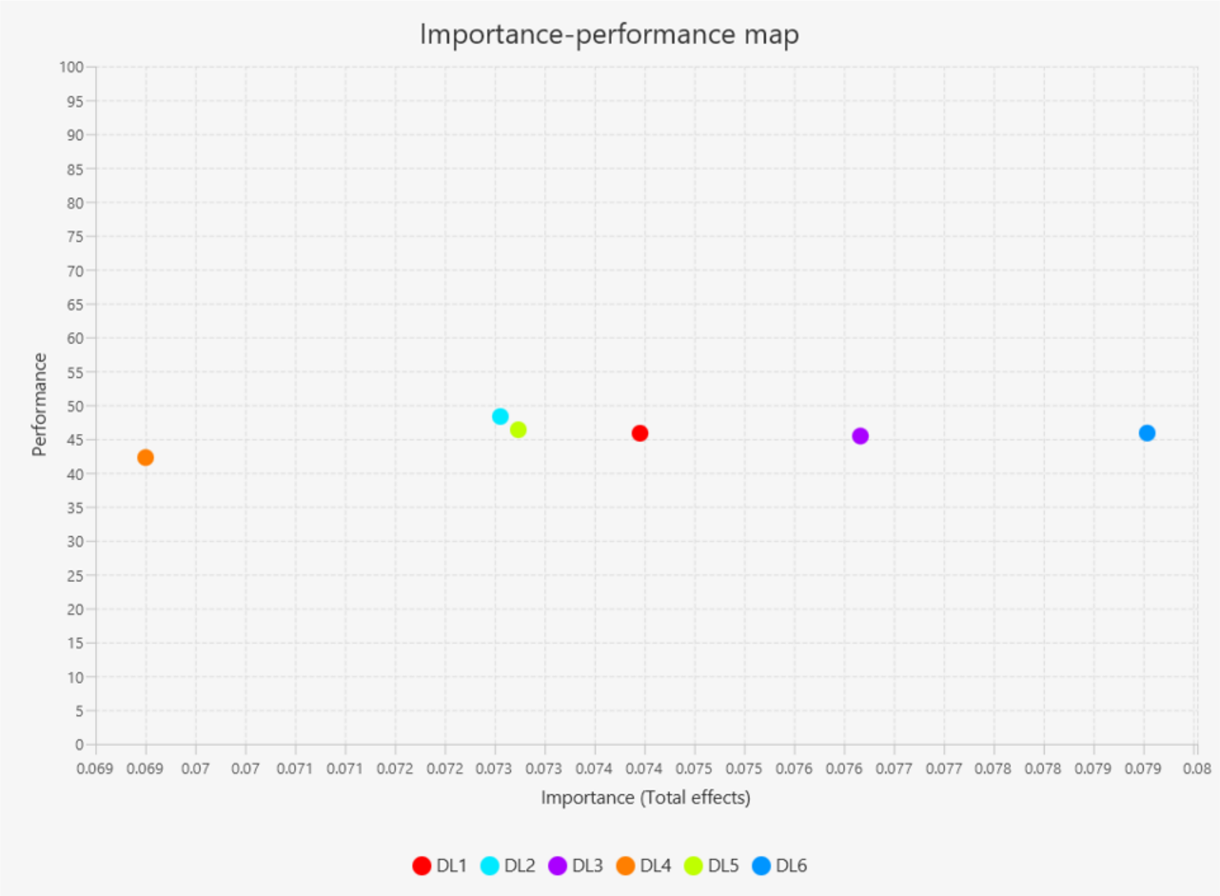

Figure 3.
The importance-performance map and academic impact.

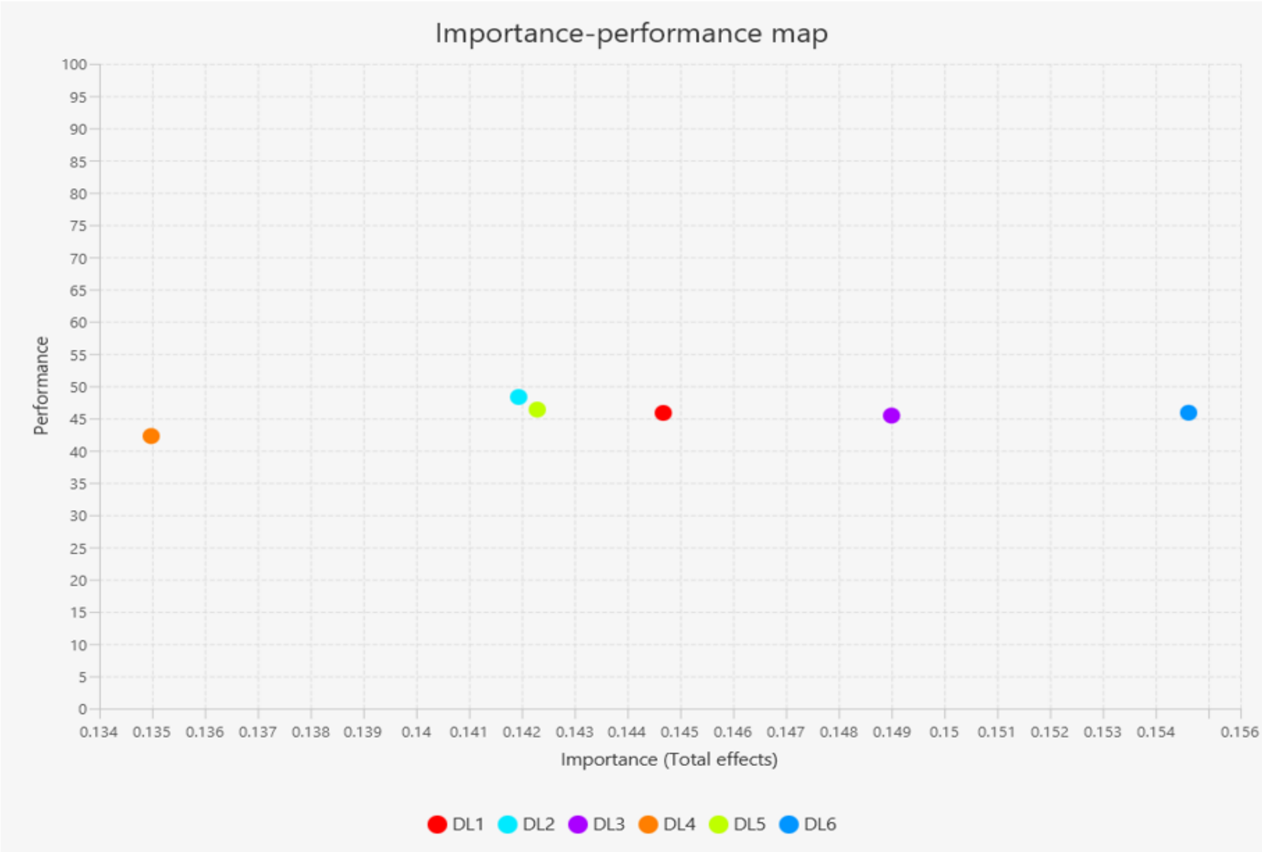

Figure 4.
Importance of performance map research enhancement.

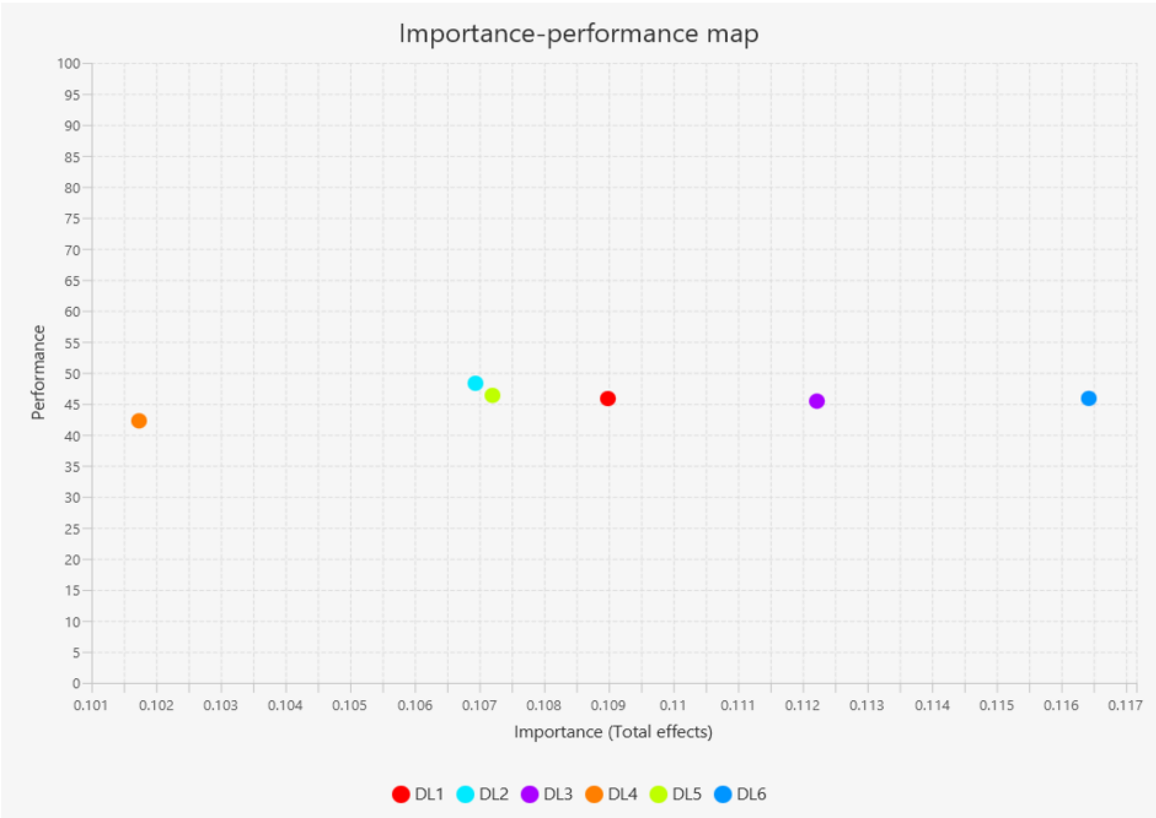

Figure 5.
The importance-performance map and social relevance.

Table 6.
Hypothesis testing.

Hypotheses	**Paths**	**Original sample (O)**	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	**P values**	**Remarks**
Arts and humanities							
H1(AH)	Deep learning -> Academic impact	-0.149	-0.174	0.082	1.813	0.070	Rejected
H2 (AH)	Deep learning -> Research enhancement	0.58	0.589	0.054	10.832	0.000	Accepted
H3(AH)	Deep learning -> Social relevance	-0.138	-0.013	0.168	0.817	0.414	Rejected
Social science and management							
H1 (SSM)	Deep learning -> Academic impact	0.465	0.468	0.063	7.358	0.000	Accepted
H2(SSM)	Deep learning -> Research enhancement	0.684	0.687	0.037	18.397	0.000	Accepted
H3(SSM)	Deep learning -> Social relevance	0.383	0.386	0.064	5.936	0.000	Accepted
Science and engineering							
H1 (SE)	Deep learning -> Academic impact	0.739	0.74	0.034	21.614	0.000	Accepted
H2(SE)	Deep learning -> Research enhancement	0.725	0.727	0.034	21.329	0.000	Accepted
H3(SE)	Deep learning -> Social relevance	0.772	0.773	0.031	25.229	0.000	Accepted
Medical and applied science							
H1 (MAS)	Deep learning -> Academic impact	0.067	0.075	0.075	0.895	0.371	Rejected
H2 (MAS)	Deep learning -> Research enhancement	0.581	0.583	0.05	11.647	0.000	Accepted
H3(MAS)	Deep learning -> Social relevance	0.681	0.685	0.036	19.047	0.000	Accepted

Table 6's hypothesis testing analysis offers significant and illuminating perspectives on the arts and humanities. A p-value of 0.070 and a t-statistic of 1.813 indicate that the null hypothesis (H1) stating a correlation between academic impact and deep learning is rejected. There does not appear to be enough data to show a substantial effect on academic achievement according to these numbers. Still, the evidence for H2 which links deep learning to scientific progress is quite strong. Deep learning appears to have a notable and positive impact on research as supported by a substantial t-statistic of 10.832 and a p-value of 0.000. The results do not support the third hypothesis which states that deep learning is associated with social significance. We do not have sufficient information to conclude that there is a substantial influence on social relevance (t-statistic = 0.817, p = 0.414). Deep learning's complex effects on the arts and humanities are shown by these results which also reveal that it has a clear benefit in improving the quality of research but less effect in the social and academic realms.

The important relationships between deep learning and several fields of management and social science are highlighted by these ideas. Significant empirical data supports the first hypothesis (H1) which proposes a positive relationship between deep learning and academic influence. There is substantial evidence to support this conclusion, indicating a considerable influence on academic effort results as shown by the t-statistic of 7.358 and the p-value of 0.000. Hypothesis 2 also suggests a link between deep learning and better research. A high t-statistic of 18.397 and a p-value of 0.000 demonstrate that the study efforts have a substantial favorable effect. With a t-statistic of 5.936 and a p-value of 0.000, we can see that deep learning has a considerable impact on societal elements, lending strong support to hypothesis 3 which proposes a link between the two. The provided data shows that deep learning has improved the social, academic, and scientific parts of management and social science.

Deep learning's benefits in many domains are well-supported by scientific and technical principles. The statistical evidence strongly supports the first hypothesis (H1) which states that there is a relationship between deep learning and its effect on educational attainment. A strong and positive effect on academic achievement is indicated by the statistically significant t-statistic of 21.614 and p-value of 0.000. The second hypothesis is that deep learning and progress in science go hand in hand. A greater t-statistic of 21.329 and a p-value of 0.000 support the hypothesis which implies a significant positive effect on research efforts. In addition, there is a lot of evidence to back up hypothesis H3 which states that deep learning and social relevance go hand in hand. There is substantial proof of a significant impact on social components as shown by the t-statistic of 25.229 and the p-value of 0.000. Researchers, scientists and the general public may all benefit from deep learning as this study shows through its positive effects in the STEM disciplines.

The ideas shed light on the complex ways in which deep learning is influencing fields like applied science and medicine. A t-statistic of 0.895 and a p-value of 0.371 show that the null hypothesis (H1) claiming a connection between deep learning and academic impact is not well-supported. This disproves the idea. It would seem that deep learning does not significantly affect academic performance in this case. Still, there's solid proof to back up hypothesis 2 which states that deep learning is linked to better research. A substantial and positive effect on research efforts is shown by the t-statistic of 11.647 and the p-value of 0.000. With a t-statistic of 19.047 and a p-value of 0.000, the third hypothesis is highly supported showing a substantial link between deep learning and social relevance. It seems that society has been positively affected by this. Here, we show that deep learning has far-reaching consequences in the fields of applied science and health and that these consequences vary between areas.

5. Findings and Discussion

Deep learning transforms educational practices, research methods and societal implications across the arts and humanities, social sciences, engineering, health and management marking a paradigm shift in education and knowledge dissemination. Deep learning which combines artificial intelligence and machine learning has created a new era of personalized learning [56], adaptive teaching and innovative research methods that have improved academic performance and research across many fields [57]. Deep learning's capacity to analyze large datasets, find complicated patterns, and provide actionable insights that standard methods cannot demonstrate its transformative potential [58]. Teachers and researchers across academic fields are using deep learning techniques to improve teaching, foster interdisciplinary collaboration and innovate research.

Deep learning has a greater impact on science and technology domains than on others. Deep learning has transformed diagnostics, predictive modeling [59] and drug development in engineering and health sciences. It has enhanced healthcare and scientific research. Management studies use deep learning in analysis to evaluate huge data, forecast market trends, influence strategic decision-making and improve business performance giving them an advantage over competition. However, while deep learning has shown promising results in the art, the humanities and social sciences, its application may require more delicate, careful consideration in the context of ethical consequences. To maximize the benefits of deep learning and minimize the risk, it is important to have ethical considerations, model interpretability, and appropriate resource allocation. We have seen challenges incorporating data privacy, algorithmic bias, and transparency. Deep learning models' interpretability is important for stakeholders to develop trust and understanding especially in domains where decisions have major social impacts. It is important to allocate resources responsibly to avoid negative stimuli in education and research gaps.

Interdisciplinary collaborations, long-term planning, and strategic investments are recommended to maximize deep learning in the field of academics and society. Interdisciplinary collaborations among teachers, academicians, policymakers, and industry stakeholders can significantly promote knowledge exchange, innovation diffusion and the co-creation of complex societal solutions. In terms of long-term planning that inculcates establishing sustainable methods and infrastructure that integrate deep learning technology into the educational curriculum. Investments in R&D and infrastructure are needed to build the capability to stimulate innovation and assure the long-term scalability and sustainability of deep learning programs.

The present research on deep learning across academic fields states its potential to enrich education, research and society. Deep learning enables individualized learning, interdisciplinary cooperation and research innovation using AI and machine learning [60]. Deep learning's full benefits require careful evaluation of ethical, social and technical considerations and proactive measures to overcome difficulties and inequities. Interdisciplinary collaborations, long-term planning and strategic investments can help stakeholders maximize deep learning's positive effects and help education and society become more egalitarian and inclusive [61]. Hence, our study supports previous research reinforcing the deep learning implications in the development of learning experiences.

6. Conclusion

The present research attempts to illustrate deep learning transformations in diverse academic fields. This study explores how deep learning has a significant impact on learning among students in higher degree programs. This research also emphasizes the significance of deep learning in the interdisciplinary framework of academia to maximize deep learning benefits. This emphasizes the need for cross-disciplinary collaboration to stimulate innovation and knowledge exchange.

This study illustrates the way deep learning transforms arts and humanities, social sciences, engineering, health, and management studies. A comprehensive academic and empirical data study shows that deep learning has greatly impacted education, research and society. Personalized learning, adaptive teaching and innovative research have improved academic achievement and interdisciplinary collaboration by using artificial intelligence and machine learning. Deep learning is promising in science and technology but its use in the arts, humanities and social sciences requires careful consideration. Responsibility for implementation and resource allocation is needed due to data privacy, algorithmic bias and model interpretability issues. Deep learning could enhance education and society through intended research and development, interdisciplinary cooperation and long-term planning.

This study emphasizes the necessity of evaluating deep learning's ethical, social and technical aspects to overcome challenges and encourage inclusive and fair access to its benefits. Individuals can use deep learning to solve complex social issues and improve academic learning by prioritizing multidisciplinary collaboration and investing in technology and innovation. Therefore, this study adds to the expanding body of evidence demonstrating deep learning's revolutionary function in education and knowledge transmission.

6.1. Future Avenues of Research

1. Future research could emphasize developing robust ethical frameworks that can be tailored to address the unique challenges and requirements in academic fields, thereby ensuring responsible and transparent use of deep learning technologies.
2. In the domain of science and technology, deep learning exhibits a strong and significant positive impact on academic achievement and research progress, hence future research avenues can be explored for developing customized educational applications. This research could emphasize investigating how deep learning can optimize individual learning skills and research aptitude.
3. Future research could comprehensively emphasize deep learning's impact over an extended period. This could offer a deeper understanding of the sustained consequences and variations across different subdomains in different fields of study.
4. In the present study, we faced challenges associated with model interpretability resonating across various academic domains. Hence, future research could focus on developing innovative approaches that can enhance the transparency of deep learning models and ensure their interpretability in fields ranging from the arts and humanities to science and technology.
5. Balancing resource constraints across different domains is a common challenge that institutions often encounter. Future research could optimize resource allocation strategies specific to each academic discipline ensuring that the benefits of deep learning are maximized and address practical constraints.
6. Given the interdisciplinary nature of deep learning and its impact, future research could emphasize cross-disciplinary collaborations. This research could explore how deep learning can facilitate traditional learning and will open avenues for innovative applications and knowledge transfer, hence fostering a holistic understanding of its influence.

6.2. Implications of the Study

This research has far-reaching implications and extends throughout academia, technology integration and societal progress. These findings provide helpful evidence on the various implications of deep learning for academic disciplines by guiding educationalists and institutions towards optimal education practices. This study emphasizes the importance of ethical concerns in the use of deep learning thus leading to the development of responsible frameworks. Policymakers can align their resource allocation based on identified impacts by strategically integrating deep learning technologies with academic goals. The broad implications that deep learning holds for societal growth particularly in healthcare, the social sciences and technology are evidenced by its positive influences on different aspects of society. However, institutions can balance between practical considerations and the benefits derived from deep learning as they develop informed allocation strategies given the limited resources available to them. In this regard, the research therefore encourages interdisciplinary collaboration through the recognition of cross-disciplinary impacts thereby generating innovative approaches to shared problems. Moreover, longitudinal impact illuminates long-term planning that helps decision-makers anticipate changing influences and plan instructional strategies accordingly. Thus, this study aims to guide the responsible and effective integration of deep learning.

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Appendix 1.
Confirmatory tetrad analysis (CTA).

Deep learning	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Bias	CI low	CI up	Alpha adj.	z(1-alpha)	CI low adj.	CI up adj.
1: DL1,DL2,DL3,DL4	-0.002	-0.001	0.041	0.046	0.963	0.000	-0.071	0.066	0.011	2.54	-0.108	0.103
2: DL1,DL2,DL4,DL3	0.103	0.103	0.037	2.764	0.006	0.000	0.042	0.165	0.011	2.54	0.009	0.198
4: DL1,DL2,DL3,DL5	-0.060	-0.059	0.035	1.694	0.090	0.000	-0.117	-0.002	0.011	2.54	-0.149	0.030
6: DL1,DL3,DL5,DL2	0.061	0.061	0.035	1.725	0.085	0.000	0.003	0.120	0.011	2.54	-0.028	0.151
7: DL1,DL2,DL3,DL6	0.050	0.050	0.034	1.471	0.141	0.000	-0.006	0.105	0.011	2.54	-0.036	0.135
10: DL1,DL2,DL4,DL5	0.256	0.255	0.045	5.759	0.000	-0.001	0.185	0.331	0.011	2.54	0.145	0.371
16: DL1,DL2,DL5,DL6	0.026	0.026	0.030	0.879	0.380	0.000	-0.023	0.076	0.011	2.54	-0.050	0.103
22: DL1,DL3,DL4,DL6	0.025	0.025	0.033	0.753	0.451	0.000	-0.029	0.080	0.011	2.54	-0.059	0.110
26: DL1,DL3,DL6,DL5	-0.045	-0.045	0.034	1.346	0.178	0.000	-0.100	0.010	0.011	2.54	-0.130	0.040

Appendix 2.
Questionnaire.

1	**Current academic status**	**Undergraduate student**	**Graduate student (Master's)**	**Ph.D.**	**Postdoctoral researcher**	**Faculty member**
2	Academic discipline	Arts & humanities	Social science and management	Science and technology	Medical and para medical	
3	How many years have you been involved in higher education or research activities?	Less than 1 year	1-2 years	3-5 years	6-10 years	More than 10 years
	Deep learning	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
4	How frequently do you utilize deep learning techniques or technologies in your academic research or coursework?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
5	To what extent do you believe deep learning methodologies have enhanced your understanding of complex concepts within your academic discipline?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
6	Have you observed any improvements in your academic performance or research outcomes since incorporating deep learning into your studies?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
7	How confident are you in applying deep learning algorithms or models to analyze data or address research questions within your specific field of study?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
8	Do you perceive deep learning as a valuable tool for advancing knowledge and innovation in your academic domain?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
9	To what degree do you feel that exposure to deep learning has prepared you for future academic and professional pursuits in your field?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
Academic impact						
10	How would you rate the overall impact of your academic experiences on your personal and professional development?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
11	In your opinion, how significantly do factors such as deep learning methodologies contribute to your academic achievements and scholarly pursuits?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
12	Have you noticed any discernible changes in your academic outcomes or	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree

	performance since integrating deep learning approaches into your learning process?					
Research enhancement						
13	To what extent do you believe deep learning has influenced the quality and significance of your research contributions in your specific field of study?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
14	How do you perceive the role of deep learning techniques or technologies in enhancing your research capabilities or productivity within your academic discipline?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
Social impact						
15	From your perspective, how do deep learning advancements contribute to addressing societal challenges or improving community welfare within your academic domain?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
16	Can you provide any examples where deep learning applications have positively impacted social issues or initiatives outside of academic contexts?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree
17	In your opinion, how important is it for academic institutions and researchers to consider the societal implications of their deep learning research and applications within your field of study?	1= Extremely - negative/Disagree	2= Negative/ Disagree	3 =Neutral	4= Positive/ Agree	5=Extremely-positive/ Agree