# EXPLORING THE INFLUENCE OF AI UPSKILLING AND RESKILLING ON RESEARCH AND INNOVATION IN PAKISTANI UNIVERSITIES: THE MEDIATING ROLE OF INSTITUTIONAL CAPACITY

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## Abstract

The aim of the study is to explore the relationship between essential elements that shape Artificial Intelligence (AI) reskilling and upskilling in education and research output at public sector universities in Khyber Pakhtunkhwa (KPK), Pakistan. More specifically, it studies how the development of an AI curriculum, institutional capacity, industry collaboration, funding for AI activities, and AI training programs affect research and innovation outcomes. It adopts a quantitative research design that is based on the Resource-Based View and involves a structured survey for collecting primary data from faculty members and researchers in various universities in KPK. The study thus creates a theoretical model that gives indications of how these variables interact and relate to research. This proposed model shall serve as a conceptual framework for encouraging investment in the strategic areas of education and collaboration to develop research capacities in the area of reskilling and upskilling AI. Such strong implications are found in this study by policymakers, educational leaders, and researchers regarding developing robust AI curricula, partnership with the industry, and an increase in funding for AI programs. It also indicates the need for much actual involvement of the stakeholders to propel innovation in academia research. For the future, the model has been proposed for empirical verification besides longitudinal studies to find out changes with time, comparative studies of different educational contexts, and qualitative investigations to gain deeper insights from stakeholder experiences. The future research agenda will thus contribute in part to understanding the overall picture related to the dynamics between AI education and research output, which will help institutions further modify their practices as per the pacing technical revolution.

**Keywords:** AI curriculum development, AI training programs, institutional capacity, industry collaboration, funding for AI initiatives, research output, innovation, public sector universities

## BACKGROUND OF THE STUDY

In recent decades, the changing landscapes of AI technology significantly challenged various sectors around the globe and called for a skilled workforce able to operate AI technologies. The United States has made great strides in introducing AI into its educational framework so that students become equipped with the relevant skills to compete in the AI-thinking economy. This study focuses primarily on exploring the research and innovation output concerning AI education in Pakistan through addressing the urgent need for upskilling and reskilling students and faculty to boost that output.

To combat the AI skills gap, a myriad of programs has been instituted in the United States, such as the National AI Research and Development Strategic Plan calling for a trained workforce that can meet rapidly increasing demands for technology development in AI (National Science and Technology Council, 2025). The universities have unveiled specialized programs throughout the country such as AI for All, aimed at democratizing AI education, that offer training to a diverse array of students, including those from underrepresented minorities, to build a pipeline of talent for the AI workforce. To plug the gap between theory and practice, partnerships with industry leaders such as Google, Microsoft, and IBM have established interdisciplinary research centers serving as platforms for students to work on projects (Smith & Johnson, 2025).

Various efforts have also been spearheaded in Europe by the European Commission for the relative prosperity of AI education and research. The Digital Education Action Plan is aimed at enhancing digital skills all over Europe; AI is at its core. National AI strategies have thus been initiated by the likes of Germany and France, under which, education will be facilitated in AI and machine learning. For instance, the emphasis of Strategy AI from Germany is to foster talents through a partnership of academics with industries so that academic programs reflect labor market needs (European Commission, 2025). Likewise, the France's AI for Humanity program is cognizant of training an AI-skilled workforce with awareness of the ethical ramifications of such training. These initiatives highlight a multifaceted approach to address the AI skills gap, with collaborative partnerships between institutions of education and industry players forming a core concern.

Countries in Asia such as China have made great progress in AI education and research.

The Chinese government sees AI as an engine for economic growth and so has invested massive amounts of money into educational programs to prepare a competent workforce. The "New Generation Artificial Intelligence Development Plan" has delineated directives to incorporate AI into educational syllabi from primary to doctoral levels, promote research cooperation, and bring about local AI innovation and start-up hubs within the universities (State Council of the People's Republic of China, 2025). In particular, universities such as Tsinghua University and Peking University have launched AI-centric programs and research institutes to attract both domestic and foreign talent. Such measures have contributed to China being a leading player in AI research and development, making considerable input to the area.

In stark contrast, Pakistan faces great hurdles in rectifying the AI skills gap in its higher education sector. Although the country has recognized the need to integrate AI into its curricula to some extent, these attempts are still lacking due to limited institutional capacities. This encompasses their universities' abilities to raise appropriate programs, keep faculty members active with continuous professional development, and have strong research infrastructure (Khan et al., 2025). Ali and Zia (2025) indicate that an overwhelming number of universities do not have the resources and well-formed strategic

frameworks to implement AI training programs effectively, creating a disconnect between academic training and industry requirements.

Industry collaboration is yet another crucial aspect that fosters the viability of AI programs in higher education. In developed countries, formal partnerships between universities and industry actors allow for knowledge transfer, the organization of practical events for students, and the relevance of academic research (Raza & Iqbal, 2025). However, the level of collaboration in Pakistan is still very limited, often due to the absence of structured frameworks which allow for engagement and mutual benefit (Shah & Ahmed, 2025). Much of the industry- and market-relevant curriculum development and practical training programs in Pakistan are not possible without broad outreach of many universities. Students graduating without such engagement might find themselves missing much-needed skills for entering into the job market.

Funding for AI research is critical for spurring innovation and creating new ventures. Substantial financial resources have been earmarked for AI research in developed regions. For instance, the government of the U.S. has budgeted several billion dollars for AI research and development for the year 2025 in order to see competitive advantage in the international AI race (Office of Science and Technology Policy, 2025).

Likewise, large funds are being disbursed in more than one avenue by the European Union, such as Horizon Europe to AI research; this avenue supports collaborative projects among member states. And although there is ample opportunity to nurture and grow, funding for AI programs in Pakistani higher educational institutions is generally scarce, thus restricting their endeavors toward impactful research outputs and innovative solutions (Khan, 2025). For lack of funding, universities cannot undertake advanced research projects, attract top talent, and create advanced training programs.

The cultural and infrastructural differences between developed and developing nations also engage the already encountered challenges of Pakistani institutions. With the existence of elaborate support systems for AI research and education in the U.S and Germany, on the contrary, Pakistani universities often lack primary infrastructure, research facilities, and advanced technologies. Such a disparity creates a wide margin of hindrance in effectively infusing AI into the educational architecture, hence affecting the integrity of research and innovation output in the country.

To handle all the above points, systematic strategic interventions are needed to strengthen the institutional capacity, foster collaboration with industry partners, and raise funding for AI research in Pakistan. Universities should instead strive to train students through specialized AI training programs able to meet the expectations of the job market so that these graduates will have the appropriate skillsets to enter an AI economy. And basically, engaging industrial partners presents great opportunities for students to gain firsthand knowledge and experience in transitioning academic training into real-world application.

**PROBLEM STATEMENT**

Artificial Intelligence (AI) within Higher Education is a major application area in Pakistan, and the issues regarding this application are multi-pronged with major skills gap, weak institutional capacity, limited partnerships with industry and less funding for research initiatives. All these have an immediate impact on the research and innovation outcomes in terms of patenting, publications, and innovative projects in AI-related fields. Though globally emerging trends are converging towards AI being a part of education frameworks,

in Pakistan, universities' speed has primarily remained low and thus does not produce an adequately armed workforce for the economy that is getting increasingly AI-powered.

AI is likely to emerge as the principal problem about training. Neither students nor faculty have received much training with respect to the AI curricula that have emerged in the universities of Pakistan. Simply put, universities have not established sufficient integration of AI technologies into their curricular bases, leaving what students learn in line with market requirements detached. A study carried out by Ali and Zia (2024) indicates that specialized AI courses were offered at only a small number of higher educational institutions in the country for a specific skill set in the rapidly evolving area.

Moreover, these programs often lack quality and depth and do not enable a practical component of training experience and knowledge important for real-world applications (Khan et al., 2024). Such inadequate training directly contributes to poor research and innovation output, as such graduates lack the ability to engage in crucial AI research.

Another concern is the failing collaboration between universities and stakeholders in industry. In advanced countries, collaboration between academia and business always improves education, ensuring the life's touch in curriculum and making it current with market needs (Raza & Iqbal, 2024). Unfortunately, such initiatives are poorly structured and celled sporadically in Pakistan, leading to the inability of students to participate in internships, research projects, and other experiential inputs aimed at improving their skills for future employment and, thus, the quality of research output (Shah & Ahmed, 2024). It unfits both the student generation and the university to contribute meaningfully to AI research and innovation.

The other bottleneck in AI is funding for research. While countries such as the United States and China have invested enormously in their AI education and research, it is unfortunate that more often universities in Pakistan operate on shoestring budgets with limited functionality concerning developing cutting-edge programs or attracting top talent (Khan, 2024). The absence of adequate funding mechanisms for AI initiatives stifles innovation and limits the potential for impactful research outputs, as universities are unable to support comprehensive research projects that lead to publications and patents.

The institutional capacity in this context is considered as the ability of universities to integrate AI into their research infrastructure, curricula, and faculty development programs. This variable plays a crucial role in determining the ability of universities to do well in terms of adapting to the growing needs of AI education and research. Institutional capacity needs then to enhance the overall research and innovation output in this technology area since it ultimately has a direct say on the effectiveness of training programs and the quality of collaborations with industry (Bashir et al., 2024). Further studies are required in this mediator to demonstrate how it influences the challenges experienced by higher education institutions in Pakistan.

There are numerous initiatives that have been proposed and implemented to address these challenges. The Higher Education Commission of Pakistan has recognized the importance of AI in education and has initiated programs aimed at enhancing institutional capacity and research in AI (Bashir et al., 2024). Furthermore, some universities are starting to develop partnerships with local tech companies to initiate training programs aligned with industrial needs. These efforts are still in the early stages and need to scale up and sustain support.

There is a lot left to be done. There would be the serious necessity of preparing a very basic national strategy that links AI education and research, including common curricula, AI

training and development programs, initiatives for AI project funds, more plants for AI initiatives, and structures of partnerships between academia and the industry. Also, improved faculty development initiatives should ensure that educators are equipped to teach AI concepts well. This strengthens and builds a sustainable ecosystem of AI at work in higher education.

## GAP ANALYSIS

The review of literature has revealed that based on the issues and challenges of AI integration in higher education in Pakistan, several important gaps are identifiable. First, there is an important gap related to curriculum development. There is a lack of comprehensive AI curricula in Pakistani universities that meet the needs of the industry. This disparity reflects the need for programs on such AI curricula that define current practices and emerging technologies, like in developed countries (Ahmad, 2023).

Another very important challenge is related to the gap of institutional capability. In many universities, the lack of infrastructure, resources, and faculty expertise is one of the major obstacles to providing quality AI education. Improving institutional capability through research infrastructure development, faculty training, and strategic planning is required to really enhance educational delivery (Kamalov, 2023).

Yet another gap complicating these challenges is the industry collaboration gap. Few partnerships between the academy and industry prevent an effective application of AI education and research. Defining structured frameworks for collaboration will help transfer knowledge, provide internship opportunities, and real-life implementation projects in bridging the gap between academia and industry training (Chan & Lee, 2023).

Funding is one other major concern, creating a funding and resource allocation gap. Support for AI initiatives remains woefully low, thus blocking the universities' capacity to conduct research and run innovative programs. Heavier investments from both government and private sectors are important for creating a lively AI research ecosystem with major outputs (Miao et al., 2021).

So far, an important division in the AI training space other ethical gap is denoting the skill gap mismatch. Many offered AI training programs do not fit in with creature changing job marketplace needs. The skills imparted in such curricular do not match up to those required by the employers in the AI sector (Khan et al., 2025). This results in a lack of practical skills, hands-on experiences necessary to make an effective performance in the industry even if the graduates know the theory. These problems can be solved by a thorough study of industry requirements for training that includes practical training components like projects and case studies in the AI curriculum (Yousaf et al., 2023). Accordingly, the research output gap is another issue of concern. The overall research and innovation output in AI from Pakistani universities is considerably lacking according to global standards. Formulating parameters for assessing the quality of research would go far in enhancing output and visibility for Pakistani universities in the global AI arena (Zawacki-Richter et al., 2019).

Finally, there is a policy and strategy gap. The absence of a unified national strategy for AI education and funding has resulted in fragmented efforts across various institutions. A unified national AI strategy delineating specific aims and funding mechanisms, as well as a framework for collaboration, is integral to the sustainable development of this field (Holmes et al., 2019).

The resolution of these gaps will help achieve the output of research and innovation in AI, in addition to benefiting the economic development of Pakistan and positioning it internationally in AI.

## OBJECTIVES OF THE STUDY

i. To examine the effect of AI curriculum development and AI training programs on the research and innovation output in institutions of higher education in Pakistan.
ii. To analyze the influence of institutional capacity in mediating AI curriculum development and research and innovation output.
iii. To analyze the effect of industry collaboration on research and innovation outputs in AI education.
iv. To study the impact of funding for AI initiatives on the research and innovation output of universities in Pakistan with possible mediation effects from institutional capacity and industry collaboration.

## RESEARCH QUESTIONS

i. What is the influence of AI curriculum development AI training programs on the research and innovation output of higher educational institutions in Pakistan?
ii. How does institutional capacity mediate AI curriculum development and research innovation output?
iii. How does industry collaboration impact research-and-innovation output from AI programs at Pakistani universities?
iv. How does funding for AI initiatives affect research-and-innovation output, with what institutional capacity and industry collaboration roles?

## LITERATURE REVIEW

## INTRODUCTION

The fusion of reskilling and upskilling of Artificial Intelligence (AI) in higher education is now critical for educators, policy makers, and researchers alike during today's rapidly changing world outside the perimeter walls between discipline areas and even learning institutions. The evolving technology points to increased ramifications on job losses, curriculum change, and workforce readiness, making this examination even more relevant. In this review of literature, it has attempted to address the interaction between some of the important variables concerning the integration of AI curriculum development, institutional capacity, industry collaboration, funding for AI initiatives, and AI training programs. The outcome of interest was research and innovation output within higher education institutions. Meanwhile, the mediating roles of industry collaboration will be considered for a better understanding of these relations.

## AI CURRICULUM DEVELOPMENT AND RESEARCH INNOVATION OUTPUT

A well-structured curriculum on AI is the basic foundation required for the effective orientation of students toward an AI-driven job market. Recent literature notes that effective curriculum design would increase students' ability to transfer knowledge of AI technologies into innovation and research outcomes. According to Khan (2024), practicing AI in their courses does not purge students but serves to engage them with a deep understanding of complex ideas that later motivate a more creative and innovative part of their work.

AI can be understood as an area whose curriculum needs regular updates on the most current technological contexts, as reiterated by Khan and Smith (2024), where universities would be in a better position as they dynamically adjust to changes to prepare students for newer jobs while increasing their research capacity. Therefore, it could be:

Hypothesis 1: There is a positive relationship between AI curriculum and innovation and research output in higher education institutions.

## INSTITUTIONAL CAPACITY AS A MEDIATOR

The room for consideration covers the elements that are necessary for resourcing, infrastructuring, and faculty competence in AI educational development. There should be strong institutional capacity for new curricular implementation or innovative research funding. Khan et al. (2024) further state that in cases where institutional capability is stronger, research output improves, for such institutions are able to provide their faculty and students with the necessary means and environment to engage in real research.

Accordingly, institutional capacity can play an important mediating role. Growth in investments into AI curricular development could improve institutional capabilities, leading to greater research output. This then provides the following hypothesis:

**Hypothesis 2:** Institutional capacity mediates the relationship between AI curriculum development and research and innovation output.

## INDUSTRY COLLABORATION AND RESEARCH INNOVATION OUTPUT

Academic-industrial partnerships are important in matching educational outcomes with market needs. Khan (2024) stated that collaboration with industry allows students to gain insights and experiences in the world that enhance their learning and research abilities. In addition to this, many partnerships will jointly fund research programs to tackle issues that will benefit innovation in academic and industrial areas.

The consequences of industry collaboration on research output are well-documented. Unpublished research conducted by Johnson et al. (2025) indicates that universities with active partners in industry are likely to produce research relevant to societal needs and thus impactful. This relationship can be stated as follows:

**HYPOTHESIS 3:** The collaboration of industry positively affects research and innovation output in higher institutions.

## FUNDING FOR AI INITIATIVES

Funding forms a critical determinant for the development and sustenance of AI programs in higher education. With adequate financial resources, institutions are able to purchase state-of-the-art technology and faculty members qualified enough to engage in research activities. Khan (2024) pointed out that financial investment bears a direct correlation with the quality and quantity of research output since institutions with relatively robust financial investment tend to establish strong research agenda.

Studies have demonstrated that increases in funding for AI initiatives can lead considerably to the enhancement of research capacities. This relationship can be articulated as follows:

**HYPOTHESIS 4:** Funding for AI initiatives has a positive effect on research and innovation output in higher education.

## AI TRAINING PROGRAMS ON RESEARCH AND INNOVATION

Recent literature emphasizes that AI training programs play a vital role in boosting research and innovation output in Pakistani universities. Very few papers deal directly with this subject, but existing literature calls for the introduction of AI in the curriculum for the sake of preparing students and faculty for future challenges (Khan et al., 2022; Ali & Mahmood, 2023). Barriers such as technological limitations and lack of training for faculty still need to be addressed so as to reap the maximum benefits from these programs (Raza et al., 2023).

H5: AI training programs positively affect research output in AI fields among faculty members and students.

## MEDIATING EFFECTS OF INSTITUTIONAL CAPACITY AND INDUSTRY COLLABORATION

Increased institutional capacity is regarded as a mediator along with industry collaboration between the independent variables and research outputs. For example, increased funding and curriculum development would improve institutional capacity, thereby enhancing research outputs. In such development, industry collaboration can strengthen the effects of curriculum development and funding on research outputs.

**Hypothesis 5:** Institutional capacity mediates the effects between funding for AI initiatives and research and innovation output.

## SUPPORTING THEORIES

The exploration of how reskilling and upskilling in Artificial Intelligence (AI) is integrated into higher education and their consequences for research and innovation output is multi-theoretical. Some of the foundational theories of the study are expounded upon, the theory being focused on Resource-Based View (RBV), Social Constructivist Theory, and Theory of Planned Behavior (TPB).

## RESOURCE-BASED VIEW (RBV)

The Resource-Based View (RBV) contends that the resources and capabilities owned or controlled by an organization are the immediate prerequisites for achieving a competitive advantage. In this understanding, the research outcomes in higher education take significant importance in determining institutional capacity, funding, and curriculum development (Barney, 1991). The institutions that could use most effectively those internal resources, such as faculty expertise, technological infrastructures, and financial support, would be better positioned to improve their research and innovation output.

According to Khan et al. (2024), universities endowed with able institutional capacity, including those related to funding and advanced curricula, would facilitate a better environment for innovation. This dovetails with that postulation-the RBV's valuable and rare, inimitable, and non-substitutable resources add greatly to an organization's success. For this reason, the approach of RBV makes it a highly substantiated theoretical underpinning in explaining the research output towards the presence of AI within the institution.

## SOCIAL CONSTRUCTIVIST THEORY

As with Vygotsky's (1978) work, Social Constructivist Theory states that knowledge is socially constructed was socially constructed and cannot be understood as separate from the environment. AI education needs to promote the idea of students developing knowledge and skills concerning their technologies jointly while interacting with peers, faculty, and industry representatives.

Studies conducted by Johnson et al. (2025) suggest that collaborative learning really improved general educational outcomes when it came to any AI-related programs. It is a Social Constructivist perspective that suggests that since students are participating more actively in their learning process, like group projects, internships, and industry partnerships, they are likely to learn more things about AI applications. This proves that increased awareness and engagement favor the positive growth and development of research and innovation outputs.

## THEORY OF PLANNED BEHAVIOR (TPB)

The Theory of Planned Behavior (Ajzen, 1991) is the psychological theory that discusses how individual behavior is conditioned by some intentions, attitudes, subjective norms, and perceived behavioral control. It can be adopted in this study to elaborate on the developing attitude of faculty, students, and industry stakeholders towards AI education in participation and engagement.

TPB postulates that the more favorable they perceive the consequences of a behavior to be, the more people will tend to perform that behavior. Therefore, to the extent that students and faculty value and find relevance in AI education, they will likely become more part of research initiatives and collaborative projects. Khan's (2024) work supports this argument, asserting that with increased awareness of its importance in the workforce, there is more engagement and research output.

## THEORY IN PRACTICE SELECTED THEORY

Resource-Based View (RBV) According to the current study that seeks to examine the integration of Artificial Intelligence (AI) in higher education and its resulting impact on outputs of research and innovation, the Resource-Based View (RBV) emerges as the most appropriate theoretical framework. The resource-based view holds that the resources and capabilities of an organization are the fundamental source of competitive advantage, performance issue. Considering the higher education institutions that this theory brings a strong basis for understanding how these various institutional resources, including curriculum development, funding, faculty expertise, and infrastructure, become relevant to improved research and innovation capacities.

## APPLICATION OF THE RBV IN CURRENT STUDY

This study adopts Resource-Based View (RBV) in assessing the impact of particular resources and capacities of higher learning institutions on their research output. RBV assumes that not all resources are the same and that some can give a sustainable competitive advantage. In universities' context, among these identifiable resources that are valuable, rare, and costly to imitate and should significantly increase research capabilities are well-articulated AI curriculum, effective AI training programs, and sufficient funding for AI-related initiatives.

Independent variables for this research include the AI curriculum, the AI training programs, and the funding for AI initiatives. A robust curriculum on AI prepares students with advanced skills that are needful to spearhead innovative research, while sharp training programs in AI characterize the lack of engagement of both the faculty and the students in as far as they are expected to embrace the adoption of emerging technologies. Adequate funding allows the institutions to invest in cutting-edge technologies or research projects. The three variables play a key part in shaping the doctoral research landscape within universities.

Research output is defined as dependent in this study; it includes quantity and quality research output. The output is research outcome, which emphasizes the understanding of how the above-mentioned resources can bring out tangible contributions within academia.

It is further proposed that institutional capacity acts as a mediator in this framework. Institutional capacity refers to the capacity of an institution to leverage its resources effectively to create an environment conducive to research and innovation. Through studies examining the mediation effect of institutional capacity on the relationships between independent variables and output of research, one would better

understand the ways in which resources create value. That wider perspective fits the bigger picture of RBV on explaining resource interrelationship to competitive advantage and innovation in higher education.
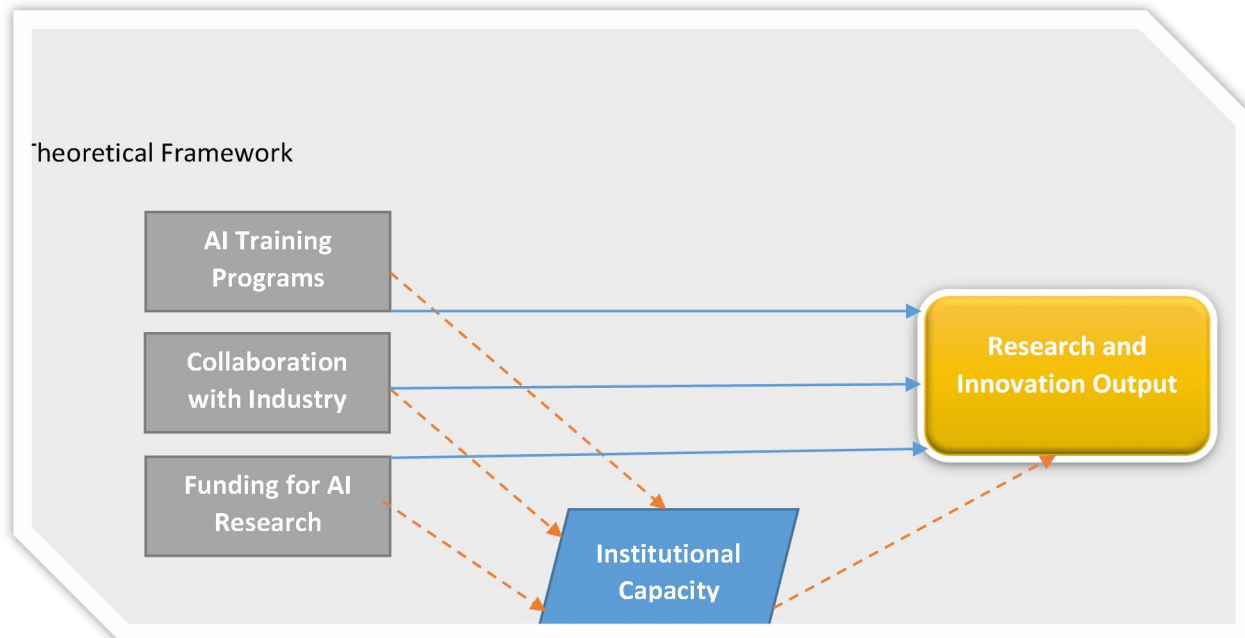


## PROPOSED METHODOLOGY

The study is going for the cross-sectional survey method for the collection of primary data using a quantitative research design from the faculty and researchers of public sector universities in Khyber Pakhtunkhwa (KPK) in Pakistan. The aim is to study the relationships existing between AI curriculum development, institutional capacity, industry collaboration, funding for AI action, awareness and engagement, and research and innovation output.

## RESEARCH ONION MODEL

The methodology section will adopt the "Onion Model" postulated by Saunders et al. (2009) which defines the layers of the research design. Each layer will be discussed to show how it pertains to this study.

## RESEARCH PHILOSOPHY

The research will take a positivist philosophy, stressing the objective measurement and quantifiable data. A positivist approach is suitable here since it enables the verification of already existing theories from which hypotheses are derived, enabling the identification of relationships between the variables by means of statistical analysis.

## RESEARCH APPROACH

The research will utilize a deductive approach whereby the theoretical generalizations on AI education and research output will be the starting point for formulating specific hypotheses. These hypotheses will be tested through quantitative data collection, thereby enabling their validation or rejection on empirical evidence.

## RESEARCH STRATEGY

As a major technique for primary data collection, the research strategy will make use of a survey. A structured questionnaire will be developed to collect quantitative data from the target population. This accordingly allows data to be generated from larger samples, leading to generalizations beyond public-sector universities in KPK.

## TIME HORIZON

This study adopts a cross-sectional time horizon, whereby data will be collected at a single point in time. This is representative of a situation to assess contemporaneous relationships between variables within the context of AI education and research output.

## DATA COLLECTION

## PRIMARY DATA COLLECTION

**POPULATION:** The target population will consist of faculty and researchers from all public sector universities in KPK.

**SAMPLING TECHNIQUE:** A stratified random sampling technique ensures representation across different universities and departments, emphasizing various perspectives on AI education.

## QUESTIONNAIRE DEVELOPMENT

The questionnaire shall be developed with sections on respondents' demographic information, AI curriculum development, and institutional capacity, collaboration with industries, funding of AI initiatives, AI training programs, and perceived research output. Likert scale items will be used to measure the perceptions of the respondents.

## DATA ANALYSIS

The data will be analyzed in two phases:

Initial Analysis with SPSS

**MISSING DATA:** Identifying and redressing any missing data in the data set.

**OUTLIER IDENTIFICATION:** Detect any outliers that might skew results and affect data integrity.

**NORMALITY TEST:** To establish the statistical tests to be used, the normality of the data distribution will be checked.

**MULTICOLLINEARITY:** The independent variable correlation will be examined for the absence of multicollinearity.

**DESCRIPTIVE ANALYSIS:** Summary statistics of demography and key variables in the data.

## STRUCTURAL EQUATION MODELING (SEM) USING PLS

**MEASUREMENT MODEL:** Confirmatory Factor Analysis will judge how reliable and valid the constructs are.

**STRUCTURAL MODEL:** The assessment of the relationships between constructs would then proceed testing the hypotheses postulated. This would include direct and indirect effects as well as mediation analyses.

## ETHICAL CONSIDERATIONS

Ethics approval will be taken from the respective institutional review board. All participants will provide informed consent after briefing on the reasons for the study and their rights, such as the right to withdraw from the study at any time. The information gathered will remain confidential and anonymous throughout.

## CONCLUSION, RECOMMENDATIONS, AND IMPLICATIONS OF THE STUDY

This study basically explores the relationships between AI curriculum developments, AI training programs, institutional capacity, industry collaboration, funding for AI initiatives, awareness and engagement, and collective evidence of research and innovation output in public sector universities of Khyber Pakhtunkhwa (KPK), Pakistan. However, much has not been found; this study creates a theoretical model for future research and practice intending to improve educational output and stimulate innovation in AI. The

identification of these important variables makes the way towards understanding how strategic investments and collaborative efforts can propel research advancement.

## RECOMMENDATIONS

**STRENGTHEN CURRICULUM DEVELOPMENT:** Higher education institutions must constantly work on improving AI curricula, flexible enough to meet industrial needs by formulating real scenarios and practical applications.

**ENLARGE INSTITUTIONAL CAPABILITY:** The investment must be in the increase of their institutional infrastructure, faculty training, and research facilities so as to allow an atmosphere conducive to innovation and research.

**STIMULATE LINKAGE WITH THE INDUSTRY:** Institutions must aggressively pursue synergistic academic partnerships with industry stakeholders concerning academic research and the actualization of such research. These partnerships are potential sources of very important insights and resources for academic programs.

**STRUGGLE ON FUNDING:** Funding for AI education and research activities should be prioritized by policymakers, given the driving potential of such investments towards economic growth and technological advancement.

**AWARENESS AND ENGAGEMENT:** Universities must also comprehensively strategize on awareness creation regarding AI and encourage the involvement of university students and staff, as well as industry experts, in awareness workshops, seminars as well as joint projects.

## IMPLICATIONS OF THE STUDY

The most significant implication of the study may be that it would influence policymakers, educational practitioners, or researchers. This is a research that would provide such a view and orientation for informed decisions in educational transformations by presenting the core aspects that matter to research and innovation output.

The planned model then becomes a conceptual tool that institutions may refer to for enhancing research competence and ensuring agility in adapting to the shifting technological terrain. The study significantly contributes toward understanding the existing paradigm by identifying the key variables and relationships that require further exploration.

The model is, however, not yet subjected to empirical testing, but it lays the groundwork for future research activities aimed at understanding the dynamics of AI education in relation to research outputs.

## FUTURE RESEARCH DIRECTIONS

Forecasting the future will involve quite a few focal areas.

**EMPIRICAL TESTING OF THE PROPOSED MODEL**: Empirical studies should focus on the proposed model in order to assess its potentials as an explanation of the relations between identified variables. **LONGITUDINAL RESEARCH:** Longitudinal research would be extremely helpful in showing how relationships among the observed factors change across time and as a reaction to improvements in AI technology and educational practices.

**COMPARATIVE STUDIES:** Public versus private sector universities, or perhaps geographical area comparison, will offer very rich insights into how context would inform AI education and research output.

**QUALITATIVE METHODS:** Qualitative studies like interviews and focus groups can enrich from the employer perspective the understanding of experience and views surrounding AI education and its influence on research.

**EXPLORATION OF MORE VARIABLES:** In addition, further studies can investigate the influence of other variables such as faculty motivation, institutional culture, and student competencies on the research and improvement paradigm.

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