INDONESIAN JOURNAL OF CURRICULUM
AND EDUCATIONAL TECHNOLOGY STUDIES
2025, Vol. 13, No. 1, 26-43, DOI: https://doi.org/10.15294/ijcets.v13i1.13393

The influence of AI adoption, research skills, and statistical knowledge on graduate students' statistical productivity

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Abstract

Ensuring statistical productivity is essential for enhancing research efficiency and quality. This study examined the correlation between Artificial Intelligence (AI) adoption, research skills, and statistical knowledge with statistical productivity among graduate students in Misamis Occidental during the academic year 2023–2024. Employing a descriptive-correlational design, 192 graduate students were selected through stratified random sampling. Data were collected using researcher-developed questionnaires and analysed using mean, standard deviation, Pearson correlation, and stepwise multiple regression analysis. The findings indicated high levels of AI adoption, research skills, and statistical knowledge, all of which were positively correlated with statistical productivity. AI engagement, research proficiency, and statistical expertise were significant predictors of statistical productivity. Active use of AI and a strong understanding of statistical concepts notably enhanced students' ability to analyse and interpret data. To further improve productivity, it is recommended that school administrators establish research centres equipped with appropriate software and tools to support research and statistical analysis.

ARTICLE HISTORY
Received 6 January 2025
Accepted 3 April 2025

KEY WORDS
AI adoption, artificial intelligence, research skills, statistical knowledge, productivity

INTRODUCTION

In contemporary academia, the integration of artificial intelligence (AI) with research methodologies (Xu et al., 2021) and statistical analysis (Guh, 2003) is significant, yet its impact on graduate students is underexplored. This study investigates how AI adoption influences graduate students' research skills, statistical knowledge, and productivity. Understanding the extent of AI adoption among students is crucial for assessing their preparedness for emerging technologies (Ali, 2023). Examining the relationship between AI adoption and research skills helps gauge critical competencies like problem-solving (Rai, 2023).

Statistical knowledge is foundational, and understanding AI's influence on it informs strategies for fostering statistical literacy (Friedrich et al., 2022). Research productivity is vital for assessing students' impact in their fields (Sevim & Sarıkaya, 2020). Hence, this study aims to uncover how AI adoption and graduate students' skills influence productivity, informing evidence-based strategies for enhancing graduate education in an AI-driven research landscape. By exploring these relationships, the study contributes to understanding how AI shapes the capabilities and outcomes of future scholars and practitioners.

The integration of AI technologies in educational settings holds immense promise, with the potential to enhance learning experiences and student performance significantly. Personalized and adaptive learning facilitated by AI-powered tools can cater to individual learning needs,

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thereby optimizing educational outcomes (Zhai et al., 2021). Understanding the impact of AI on academic achievements and attitudes toward learning becomes paramount. Such understanding not only informs the efficacy of AI-driven educational interventions but also aids in crafting engaging and personalized learning experiences like research and statistical productivity (Salas-Pilco et al., 2022). It is also crucial for enhancing instruction and learning in higher education contexts (Pacheco-Mendoza et al., 2023).

AI enhances students' learning experiences and boosts academic achievement by tailoring education to individual preferences and requirements (Hanaysha et al., 2023). Additionally, AI fosters critical thinking, problem-solving, and creativity, enabling collaborative problem-solving and project development (Alfalah, 2023; Melo et al., 2022). Personalised education facilitates access to customised materials and activities, catering to diverse learning styles (Melo et al., 2022). For instance, interactive exercises and simulations suit hands-on learners, while comprehensive academic resources like books and articles cater to those inclined toward theoretical learning (Tauber et al., 2021). This adaptability optimizes each student's learning journey and enhances their academic success.

The adoption of AI has been shown to significantly influence students' academic experiences. Studies suggest that AI-powered learning tools enhance comprehension, creativity, and productivity among students (Grájeda et al., 2024). Additionally, the use of AI in education aims to support personalised learning experiences, adaptive instructions, and intelligent tutoring systems, thereby empowering learners (Darvishi et al., 2024). AI technologies, such as AI chatbots, can streamline various academic activities in higher education institutions, including admissions processes (Dempere et al., 2023).

Artificial Intelligence (AI) can significantly enhance students' productivity in various ways. Firstly, AI-powered tools assist in statistical analysis by automating tasks such as data processing, visualization, and interpretation, allowing students to focus more on understanding statistical concepts rather than spending time on manual computations (Cisirraamos et al., 2023). Secondly, AI facilitates personalised learning experiences by tailoring statistical learning materials and exercises to individual student needs and proficiency levels, thus ensuring more effective learning outcomes (García-Martínez et al., 2023). Additionally, AI-driven platforms offer automated grading and immediate feedback on statistical assignments, promoting student engagement and enabling timely identification of areas for improvement (Dhara et al., 2022). Furthermore, AI can predict students' performance in statistical courses based on their learning behaviours, helping educators intervene early to provide the necessary support (Pacheco-Mendoza et al., 2023). Overall, AI empowers students by providing them with efficient tools, personalised learning experiences, and predictive insights, ultimately enhancing their statistical knowledge and productivity.

AI adoption is crucial for enhancing students' statistical productivity by automating routine tasks, reducing errors, and providing insights from large datasets. AI-powered tools assist students in conducting high-quality research and analysis, which is essential for informed policy decisions and improved outcomes (Priyadarshini et al., 2022). In modern research environments, AI engagement and participation are pivotal, as AI technologies can boost productivity across the economy, including research and education (Productivity Commission, 2024).

Graduate students who integrate AI into their research processes benefit from AI-powered virtual assistants that enhance productivity and reduce procrastination (Sabharwal et al., 2023). AI applications in online higher education—such as predicting learning status, performance, and satisfaction, recommending resources, conducting automatic assessments, and improving the overall learning experience—further demonstrate AI's impact on educational outcomes (Ouyang et al., 2022). This integration of AI into educational and research activities highlights its importance in enhancing students' productivity and research capabilities.

While studies have highlighted the benefits of AI in enhancing learning experiences and performance among students (Grájeda et al., 2024; Darvishi et al., 2024), there is limited research

focusing on the implications of AI adoption specifically for graduate-level education. Based on the review of the prior research, there is a population gap. Understanding how AI technologies, such as AI-powered tools and platforms, affect graduate students' research processes, statistical proficiency, and overall productivity is essential for optimising graduate education in an increasingly AI-driven research landscape. Therefore, there is a need for empirical investigations that delve into the dynamics between AI adoption and academic outcomes among graduate students, providing insights to inform evidence-based strategies for enhancing graduate education and preparing students for the demands of contemporary research environments.

Hence, this study explored the correlations between Artificial Intelligence (AI) adoption, research skills, and statistical knowledge in relation to statistical productivity among graduate students in higher education institutions in Misamis Occidental during the academic year 2023–2024. Specifically, it sought to answer the following research questions: (1) What is the level of AI adoption among graduate students? (2) What is the level of research skills among graduate students? (3) What is the level of statistical knowledge? (4) What is the level of statistical productivity among graduate students? (5) Is there a significant relationship between statistical productivity and the levels of AI adoption, research skills, and statistical knowledge among graduate students? (6) Which of the independent variables, individually or in combination, best predict statistical productivity?

The findings of this research significantly contribute to the growing body of knowledge on educational technology and research training by highlighting the predictive value of AI use, research competence, and statistical literacy in enhancing academic productivity. These insights can guide educators, administrators, and policymakers in designing targeted interventions to support graduate student research performance through improved training, resources, and infrastructure.

LITERATURE REVIEW

Artificial intelligence (AI) has significantly impacted online learning in higher education, offering new avenues for enhancing instruction and learning experiences. AI applications in online higher education include predicting learning status, performance, and satisfaction, recommending resources, conducting automatic assessments, and improving the overall learning experience (Ouyang et al., 2022). This systematic review also highlights the importance of integrating educational and learning theories into AI-enabled online learning and adopting advanced AI technologies to collect and analyse real-time process data. Furthermore, there is a need for more empirical research to test the actual effects of AI applications in online higher education (Ouyang et al., 2022).

During the pandemic, faculty members worldwide utilised AI and other technologies to sustain teaching and learning, which had predominantly been delivered face-to-face prior to the lockdowns (Crompton & Burke, 2023). However, the rapid adoption of technology left limited time to fully explore AI's potential to transform education, often resulting in the replication of traditional teaching practices rather than the utilisation of AI's affordances for innovative pedagogical strategies.

Research by Bozkurt et al. (2021) identified three key research clusters in the field of AI in education: artificial intelligence, pedagogical, and technological issues. The authors proposed five broad research themes: adaptive learning and personalisation through AI-based practices; the application of deep learning and machine learning algorithms in online learning processes; educational human–AI interaction; the educational use of AI-generated data; and the role of AI in higher education. They also emphasised the importance of addressing ethical considerations in AI research, noting that this area has been largely overlooked.

AI-based instruction has also been shown to improve students' critical thinking skills. For

example, AI-based instruction promotes students' trust, self-confidence, open-mindedness, and maturity, which helps them develop critical thinking skills—an essential foundation for 21st-century learning (Muthmainnah, Ibna Seraj, & Oteir, 2022).

AI's role in the Fourth Industrial Revolution (Industry 4.0 or 4ir) incorporates human behaviour and intelligence into machines or systems. AI-based modelling is crucial for building automated, intelligent, and smart systems that address real-world issues across various domains, including business intelligence, finance, healthcare, visual recognition, smart cities, IoT, and cybersecurity (Sarker, 2022). Future aspects of AI point toward automation, intelligence, and smart computing systems, highlighting the need for in-depth analyses to achieve reliable and realistic outcomes.

Ethical issues surrounding AI present challenges for both researchers and educational practitioners. The risks of exposing, sharing, or misusing individual student data can be significant (Siau & Wang, 2020). Additionally, teachers' attitudes toward AI can influence its effectiveness in education. Teachers may range from resisting AI due to inadequate professional development to overreliance based on unrealistic expectations (Siau & Wang, 2020).

The research questions concerning AI adoption in education can be categorised into three layers: development, application, and integration. At the development layer, areas such as classification, matching, recommendation, and deep learning are explored. The application layer includes feedback, reasoning, and adaptive learning, while the integration layer encompasses affective computing, role-playing, immersive learning, and gamification. Furthermore, emerging research trends—such as the Internet of Things, swarm intelligence, deep learning, and neuroscience—as well as the evaluation of AI in education, have been proposed for further investigation (Siau & Wang, 2020). Challenges in the educational context arise from the inappropriate use of AI techniques, the evolving roles of teachers and students, and various social and ethical concerns. The insights from this study reinforce the theoretical foundation of AI in education and offer a promising pathway for collaboration between educators and AI engineers in future research.

With the implementation of appropriate teaching tools and pedagogical support, the focus of AI education has shifted from being purely technology-oriented to adopting an interdisciplinary design. Global initiatives have begun to incorporate AI literacy into educational standards and strategic frameworks. These efforts establish a research base for educators and scholars to develop pedagogical strategies and curricula that employ appropriate technologies, aiming to prepare students to become responsible and informed citizens in today's rapidly evolving AI-driven economy (Ng et al., 2023).

Generative AI, exemplified by ChatGPT, has had a significant impact on the construction sector by enhancing collaboration and knowledge dissemination. These AI models give professionals instant access to extensive information repositories, aiding in well-informed decision-making and fostering innovation (Rane, 2023). The adoption of expansive language models like ChatGPT in the building and construction industry holds the potential to create a future marked by intelligent, ethical, and inclusive practices. Responsible implementation of these technologies is crucial to ensure a harmonious relationship between humans and AI in the ever-evolving industry (Rane, 2023).

The rapid development of AI, a general-purpose technology, presents both opportunities and challenges for firm performance. AI technology is positively associated with productivity and employment, and it influences workforce composition by reducing the share of the labour force with college-level and below educational qualifications (Yang, 2022). AI tools may outperform humans by using deep learning models to analyse past data and simulate scenarios based on big data (Yang, 2022). Generative AI tools hold the potential to increase human productivity and disseminate best practices, aiding newer workers in learning and improving customer sentiment and employee retention (Peng et al., 2023; Brynjolfsson et al., 2023).

METHOD

The research design employed in this study combines descriptive and correlational approaches. These quantitative methods are well-suited for identifying relationships between two or more variables. Specifically, correlational studies involve examining the associations among naturally occurring variables without manipulating them, thereby allowing the researcher to explore potential relationships as they exist in real-world contexts (Bandari, 2021).

In alignment with this methodological approach, the study was conducted at one of the graduate schools within a higher education institution in Misamis Occidental. A total of 192 graduate student respondents (n = 192) were selected from a population of 382 students enrolled in the graduate school. The sample size was determined using the Raosoft online sample size calculator to ensure adequate statistical power. To achieve representative coverage, stratified random sampling was employed, with respondents proportionally selected from each programme or stratum within the graduate school.

In order to ensure relevance and consistency, participants were required to meet specific eligibility criteria. These included current enrolment in the graduate school and successful completion of Research and Statistics courses within one of the graduate programmes offered. This ensured that all respondents possessed the foundational knowledge necessary to engage meaningfully with the survey content and that the data collected would be valid for examining statistical productivity in the context of AI adoption, research skills, and statistical knowledge.

Furthermore, to gather the necessary data, four structured questionnaires were employed as the primary instruments. The Artificial Intelligence (AI) Adoption Questionnaire consisted of 25 items rated on a four-point Likert scale, measuring constructs such as AI knowledge, skills, integration in research, awareness, engagement, and participation. The Research Skills Questionnaire included 40 items, also rated on a four-point scale ranging from 5 (always) to 1 (never), designed to assess the respondents' proficiency in various aspects of research. The Statistical Knowledge Questionnaire comprised 20 items evaluating respondents' understanding of statistical concepts using a four-point Likert scale. Similarly, the Statistical Productivity Questionnaire measured the degree of statistical productivity through 20 items on a four-point scale.

A rigorous validation process was undertaken to establish the reliability and appropriateness of the research instruments. The four questionnaires were reviewed by subject matter experts to verify content validity and were subsequently pilot-tested with a group of 30 participants. The Cronbach's alpha coefficients obtained—.899 for the AI Adoption Questionnaire, .923 for the Research Skills Questionnaire, .783 for the Statistical Knowledge Questionnaire, and .802 for the Statistical Productivity Questionnaire—indicated strong internal consistency, confirming the reliability of each instrument for use in the study.

Following ethical approval from the Graduate School, the research team developed an online survey using Google Forms, incorporating a participant consent form and the four validated instruments. The digital format allowed for efficient data collection and broad reach across the graduate student population. Completed responses were automatically recorded and compiled into a Microsoft Excel spreadsheet for organisation and preparation prior to analysis.

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics—namely means and standard deviations—were calculated to describe the levels of AI adoption, research skills, statistical knowledge, and statistical productivity. To examine the relationships among these variables, the Pearson Product-Moment Correlation Coefficient was applied. Additionally, Stepwise Multiple Regression Analysis was employed to determine which independent variables—AI adoption, research skills, or statistical knowledge—most significantly predicted statistical productivity. This analytical approach provided empirical insights into the factors contributing to graduate students' statistical performance and highlighted key areas for pedagogical and institutional development.

RESULT AND DISCUSSION

A. Level of Artificial Intelligence (AI) Adoption Among Graduate Students

Table 1 presents the level of AI adoption among graduate students across various constructs, including knowledge and understanding, skills and proficiency, integration in research, application awareness, and engagement and participation. Overall, the level of AI adoption was high (M = 3.78, SD = .80), indicating a positive trend in the integration of AI-related knowledge, skills, and practices into students' academic pursuits. Graduate students are actively incorporating AI tools, techniques, and methodologies into their research, coursework, and other academic activities. This high level of adoption reflects an awareness of AI's potential to enhance productivity, efficiency, and innovation across disciplines. It also suggests a proactive approach among graduate students to stay current with technological advancements and leverage AI to tackle complex academic challenges.

Table 1 Level of AI Adoption Among Graduate Students

Constructs	M	SD	Remarks
Knowledge and understanding	3.78	.69	High
Skills and Proficiency	3.83	.79	High
Integration in Research	3.77	.81	High
Application Awareness	4.05	.67	High
Engagement and Participation	3.49	1.03	High
Overall Level of AI Adoption	3.78	.80	High

Scale: 4.20-5.0 (Very High); 3.40-4.19 (High); 2.60-3.39 (Moderately High) 1.80-2.59 (Low); 1.0-1.79 (Very Low)

The graduate students also demonstrated high levels of AI adoption in application awareness (M = 4.05; SD = .67), skills and proficiency (M = 3.83; SD = .79), knowledge and understanding (M = 3.78; SD = .69), integration in research (M = 3.77; SD = .81), and engagement and participation (M = 3.49; SD = 1.03). These findings point to a generally high level of adoption across all areas.

Building on this, students exhibit a clear understanding of how to apply AI in their research, coursework, and academic activities. They are well-versed in relevant AI tools, platforms, and applications within their fields, and possess the skills necessary to use them effectively. With proficiency in programming languages and data analysis, they show a solid grasp of AI fundamentals, emerging research, and ethical considerations. AI is being actively integrated into research design, data analysis, and interpretation, with students recognizing its role in improving research quality. Despite this, engagement and collaboration within the broader AI community appear to have room for growth.

This pattern suggests that while graduate students are highly aware of AI concepts and demonstrate strong application, their level of active participation lags slightly behind. Enhancing engagement through hands-on experience, collaboration with industry partners, and the inclusion of AI-centred projects in the curriculum may help bridge this gap. Targeted initiatives could foster a more balanced and comprehensive adoption of AI, ensuring that graduate students are both knowledgeable and actively involved in the evolving AI landscape.

The integration of AI technologies in educational settings offers substantial potential to enhance learning experiences and improve student performance. AI-powered tools provide tailored educational experiences by adapting to individual learning needs, optimising outcomes, and addressing diverse learning preferences (Zhai et al., 2021; Hanaysha et al., 2023). Personalised education, facilitated by AI, offers customised materials and activities that cater to a wide range of learning styles. For instance, interactive exercises and simulations benefit hands-on learners,

while academic resources such as books and articles are more suited to those who prefer theoretical learning (Tauber et al., 2021).

AI plays a significant role in enhancing students' learning experiences and improving academic performance (Hanaysha et al., 2023). By supporting comprehension, creativity, and productivity, AI-powered learning tools help students excel in their studies (Grájeda et al., 2024). In addition, AI fosters critical thinking, problem-solving, and innovation, encouraging more collaborative approaches to both project development and academic problem-solving (Alfalah, 2023; Melo et al., 2022).

Beyond learning support, AI technologies, such as chatbots, streamline various academic processes in higher education, including simplifying admissions procedures (Dempere et al., 2023). The integration of AI into educational settings promotes personalized learning, adaptive instruction, and intelligent tutoring systems, enabling students to take greater ownership of their learning journeys (Darvishi et al., 2024).

Despite their high levels of AI knowledge, proficiency, and research integration, graduate students exhibit comparatively lower levels of engagement and participation in AI-related activities. In response, graduate program coordinators are set up to organise workshops, seminars, and hackathons, as well as incorporate AI-focused projects into the curriculum. Faculty members will also play a key role by facilitating interdisciplinary research collaborations and leading discussions on AI ethics and responsible use.

B. Level of Artificial Intelligence (AI) Adoption Among Graduate Students

Table 2 presents the research skills among graduate students, measured across various constructs. The overall research skills of graduate students are rated as "Very Good" (M = 3.96, SD = .65). Among the specific constructs, information-seeking skills received the highest rating, categorized as "Excellent" (M = 4.20, SD = .57). Following closely are problem-solving skills (M = 4.09, SD = .59) and writing skills (M = 4.02, SD = .61), both rated as "Very Good." Formulating research questions (M = 3.98, SD = .58), collecting data (M = 3.96, SD = .65), and designing studies (M = 3.83, SD = .67) are also categorized as "Very Good." The lowest ratings, though still "Very Good," were given to analyzing findings (M = 3.81, SD = .75) and communication skills (M = 3.79, SD = .78).

Table 2 Research Skills Among Graduate Students

Constructs	M	SD	Remarks
Formulating Research Questions	3.98	.58	Very Good
Designing Studies	3.83	.67	Very Good
Information Seeking Skills	4.20	.57	Excellent
Problem-Solving Skills	4.09	.59	Very Good
Collecting Data	3.96	.65	Very Good
Analyzing Findings	3.81	.75	Very Good
Writing Skills	4.02	.61	Very Good
Communication Skills	3.79	.78	Very Good
Overall Research Skills	3.96	.65	Very Good

Scale: 4.20-5.0 (Excellent; 3.40-4.19 (Very Good); 2.60-3.39 (Good); 1.80-2.59 (Fair); 1.0-1.79 (Poor)

The findings indicate that graduate students excel in information-seeking skills, demonstrating their ability to locate and utilise relevant research materials effectively. Their strong performance in problem-solving and writing further reflects their capability to address research challenges and communicate their findings clearly. High ratings in formulating research questions, designing studies, and collecting data suggest a solid foundation in the essential stages of

the research process. However, slightly lower scores in analysing findings and communication skills point to areas where students may benefit from additional support to enhance their data interpretation and presentation abilities.

Research skills are fundamental to success in doctoral training, necessitating a commitment to objective inquiry and adherence to established academic principles. Research entails the systematic investigation of phenomena to draw conclusions that may, over time, contribute to the development of accepted theories (Ubi et al., 2020). The development of research skills among graduate students enhances STEM-related competencies and leadership capacity, thereby contributing to improved academic and professional outcomes. Students become proficient in navigating the research process and recognising the value of literature reviews, which enables them to conduct structured database searches and critically appraise the quality of primary studies. Furthermore, they acquire the ability to design research projects and develop an appreciation for the importance of scientific communication and the translation of knowledge into practice (Ferreira, 2022).

This finding aligns with that of Al-alem & Badarneh (2021), who reported that graduate students demonstrated a high level of scientific research skills within university settings. In light of this, it is important for institutions to strengthen these competencies by offering dedicated research training courses and enhancing the supervisory role of faculty members in guiding students through their dissertations and theses.

Building on this perspective, graduate programme coordinators and faculty members might also consider placing greater emphasis on the development of students' data analysis and communication skills. These areas can be supported through the organisation of workshops and training sessions focused on advanced data analysis methods and effective communication techniques. Furthermore, mentorship schemes that pair students with experienced researchers could offer valuable guidance and constructive feedback on research activities. Promoting collaborative research and encouraging student presentations may also contribute significantly to improving these competencies by providing meaningful, hands-on experience. Collectively, these initiatives would support a more comprehensive development of research skills among graduate students, addressing existing gaps and enhancing their overall research proficiency.

C. Statistical Knowledge Among Graduate Students

Table 3 presents the statistical knowledge among graduate students evaluated across various constructs. The overall knowledge of statistical concepts among graduate students is rated as "Very Good" (M = 3.61, SD = .81). Among the specific constructs, interpreting statistical results received the highest rating (M = 3.67, SD = .76), categorized as "Very Good." The following closely apply statistical methods (M = 3.63, SD = .86) and mastery of statistical concepts (M = 3.59, SD = .79), both of which are also rated as "Very Good." Drawing conclusions from statistical analysis (M = 3.56, SD = .83) received a slightly lower but still "Very Good" rating.

Table 3 Statistical Knowledge Among Graduate Students

Constructs	M	SD	Remarks
Mastery of Statistical Concepts	3.59	.79	Good
Applying Statistical Methods	3.63	.86	Good
Interpreting Statistical Results	3.67	.76	Good
Drawing Conclusions from Statistical Analysis	3.56	.83	Good
Overall Knowledge	3.61	.81	Good

Scale: 4.20-5.0 (Very Good); 3.40-4.19 (Good); 2.60-3.39 (Fair); 1.80-2.59 (Poor); 1.0-1.79 (Very Poor)

These findings indicate that graduate students possess a strong understanding of statis-

tical concepts and methods, as reflected in their consistently high ratings across all measured constructs. Their proficiency in interpreting statistical results suggests their ability to comprehend and make sense of complex data analyses. Similarly, their competence in applying statistical methods demonstrates their capacity to perform analyses with accuracy and rigour. Nonetheless, the slightly lower rating in drawing conclusions from statistical analysis indicates a potential area for enhancement, particularly in synthesising and interpreting research findings effectively.

Statistical knowledge is fundamental for graduate students engaged in research, serving as a cornerstone not only for academic success but also for future professional opportunities across a range of disciplines (Amaran et al., 2022). The level of statistical competence may vary depending on students' fields of study and specific research requirements. Therefore, the provision of appropriate statistical training and academic support is essential to enable students to succeed in their research endeavours, particularly in disciplines such as education (Gavin, 2024).

Mastery of statistical concepts is essential for the effective application of these techniques across diverse research contexts, including interpretive research that seeks to explore social realities (Bhattacherjee, 2019). The ability to interpret statistical results is particularly critical, as it enables students to derive meaningful insights and support evidence-based conclusions within their research. This interpretive process involves making sense of data and understanding its implications in relation to specific research questions or hypotheses (Abbadia, 2023). Advanced competencies are required to identify patterns, relationships, and anomalies in data, as well as to interpret statistical significance and assess its relevance to research objectives (Aveyard, 2021).

In light of these requirements, graduate programme coordinators and faculty members may consider implementing additional training sessions or workshops specifically focused on enhancing students' abilities to draw conclusions from statistical analyses. Providing opportunities for hands-on practice and constructive feedback on the interpretation of research findings can reinforce understanding and build confidence in this critical area. Furthermore, mentorship programmes could play a pivotal role by pairing students with experienced researchers who can offer guidance and support in statistical analysis and interpretation. Encouraging participation in collaborative research projects that involve quantitative data analysis may also contribute significantly to the development of students' statistical competence. Collectively, these initiatives will help ensure that graduate students continue to excel in their understanding and application of statistical knowledge while addressing existing gaps and strengthening their overall research proficiency.

D. Statistical Productivity Among Graduate Students

These findings indicate that graduate students are proficient in applying their statistical knowledge, demonstrating practical and well-developed skills in the use of statistical methods. Their commitment to continuous learning and professional development reflects a proactive approach to enhancing their statistical expertise. Furthermore, their high rating in statistical communication and collaboration underscores their ability to effectively share insights and work collaboratively on statistical projects. However, the slightly lower rating in research productivity in statistics suggests that, while students are capable, there may be barriers or challenges limiting their output in this area of research.

Statistical productivity refers to graduate students' ability to conduct reliable and valid statistical analyses within their research, including the effective application of methods, accurate interpretation of data, and clear presentation of findings (Zahid, 2021). Performance and productivity have become central objectives in higher education reforms (de Vries & Martínez, (2019). In this context, it is important that students carefully evaluate their readiness for MPhil and PhD studies. Those who are not fully prepared or committed may need to reconsider undertaking such programmes. At the institutional level, universities should reassess their admission processes, including entrance examinations, aptitude tests, and interviews, to ensure the selection of capable, motivated, and committed candidates. Such measures may help to reduce dropout rates and

ensure more efficient use of university resources (Zahid, 2021).

Personal, supervisory, institutional, and social support factors influence postgraduate research performance and success. Personal factors such as socio-demographic attributes, personality, competence, and efficacy significantly affect students' research performance (Zahid, 2021). The statistical productivity of graduate students can be categorized into personal, institutional, and environmental aspects. Personal factors include academic background, research skills, motivation, self-management, and workload. Institutional factors involve access to research facilities, funding, supervision, mentoring, and career development opportunities. Environmental factors encompass socio-economic context, cultural norms, and policy frameworks shaping the research and education landscape. Research in Korea found that graduate students significantly influence their supervisors' research output, with an increase in doctoral students positively correlating with professors' productivity (Kwon, 2015).

To address these findings, graduate program coordinators and faculty members should focus on enhancing research productivity in statistics. This can be achieved by providing more opportunities for students to engage in statistical research projects through collaborative efforts or partnerships with industry. Organising workshops and seminars on advanced statistical methods and research techniques can also help improve their productivity. Encouraging a culture of continuous learning and professional development by offering resources and support for further education in statistics will sustain their growth in this area. Lastly, mentorship programs can pair students with experienced researchers to guide and support them through their statistical research projects, helping them overcome any challenges they may face. These initiatives will ensure that graduate students continue to excel in their statistical productivity, addressing any gaps and further enhancing their overall research capabilities.

Table 4 presents the level of statistical productivity among graduate students evaluated across various constructs. The overall level of productivity is rated as "High" (M = 3.45, SD = 1.01). Among the specific constructs, applying statistical knowledge received the highest rating (M = 3.61, SD = .89), categorised as "High." This is followed by continuous learning and professional development in statistics (M = 3.45, SD = 1.08) and statistical communication and collaboration (M = 3.43, SD = .97), both also rated as "High." The lowest rating, though still "Moderately High," was for research productivity in statistics (M = 3.32, SD = 1.11).

Table 4 Level of Statistical Productivity Among Graduate Students

Constructs	M	SD	Remarks
Applying Statistical Knowledge	3.61	.89	High
Research Productivity in Statistics	3.32	1.11	Moderately High
Statistical Communication and Collaboration	3.43	.97	High
Continuous Learning and Professional Development In Statistics	3.45	1.08	High
Overall level of Productivity	3.45	1.01	High

Scale: 4.20-5.0 (Very High); 3.40-4.19 (High); 2.60-3.39 (Moderately High); 1.80-2.59 (Low); 1.0-1.79 (Very Low)

E. Significant Relationship Between Statistical Productivity and the Level of-Adoption of AI, Research Skills, And Statistical Knowledge Among Graduate Students

Table 5 presents significant correlations between statistical productivity and the level of adoption of AI, research skills, and statistical knowledge among graduate students. The correlations, measured using Pearson's correlation coefficient (r) and associated p-values, indicate notable associations between these factors.

Table 5 Significant Relationship Between Statistical Productivity and The Level of Adoption of I, Research Skills, And Statistical Knowledge Among Graduate\

Variables			Correlations				
			Statistical Productivity				
			Applications of Stat Knowledge	Research Productivity in Stat	Stat Communication	Continuous Learning and Prof Dev in Stat	Overall Statistical Productivity
AI Adoption	AI Knowledge and Understanding	*r*	.523**	.448**	.530**	.532**	.532**
		p	<.001	<.001	<.001	<.001	<.001
	AI Skills and Prof	*r*	.450**	.366**	.466**	.427**	.441**
		p	<.001	<.001	<.001	<.001	<.001
	AI Integration in Research	*r*	.477**	.383**	.463**	.456**	.465**
		p	<.001	<.001	<.001	<.001	<.001
	AI Application Awareness	*r*	.430**	.284**	.326**	.350**	.361**
		p	<.001	<.001	<.001	<.001	<.001
Research Skills	Formulating Research Questions	*r*	.587**	.564**	.569**	.528**	.589**
		p	<.001	<.001	<.001	<.001	<.001
	Designing Studies	*r*	.646**	.589**	.618**	.592**	.640**
		p	<.001	<.001	<.001	<.001	<.001
	Information Seeking Skills	*r*	.321**	.290**	.277**	.274**	.304**
		p	<.001	<.001	<.001	<.001	<.001
	Problem Solving Skills	*r*	.538**	.490**	.509**	.475**	.526**
		p	<.001	<.001	<.001	<.001	<.001
	Collecting Data	*r*	.533**	.505**	.534**	.507**	.545**
		p	<.001	<.001	<.001	<.001	<.001
	Analyzing Findings	*r*	.686**	.641**	.691**	.636**	.695**
		p	<.001	<.001	<.001	<.001	<.001
	Writing Skills	*r*	.635**	.590**	.616**	.577**	.633**
		p	<.001	<.001	<.001	<.001	<.001
	Communication Skills	*r*	.708**	.703**	.694**	.649**	.633**
		p	<.001	<.001	<.001	<.001	<.001
Statistical Knowledge	Mastery of Stat Concepts	*r*	.824**	.745**	.802**	.713**	.806*
		p	<.001	<.001	<.001	<.001	<.001
	Applying Stat Methods	*r*	.792**	.712**	.776**	.731**	.788**
		p	<.001	<.001	<.001	<.001	<.001
	Interpreting Stat Results	*r*	.833**	.744**	.793**	.767**	.821**
		p	<.001	<.001	<.001	<.001	<.001

Note: **p < 0.01 (Highly Significant); *p < 0.05 (Significant); p > 0.05 (Not Significant)

Significant variables (p < 0.05) in the analysis reveal compelling relationships between statistical productivity and various facets of AI adoption, research skills, and statistical knowledge among graduate students. Regarding AI adoption, significant positive correlations were found with AI knowledge and understanding (r = .523, p < .001), AI skills and proficiency (r = .450, p < .001), AI integration in research (r = .477, p < .001), and AI application awareness (r = .430, p <

.001). These findings suggest that a higher level of AI adoption, encompassing comprehension, skill mastery, integration into research practices, and awareness of its application, corresponds with increased statistical productivity among graduate students.

Similarly, research skills exhibited significant positive correlations with statistical productivity, as evidenced by formulating research questions ($r = .587$, $p < .001$), designing studies ($r = .646$, $p < .001$), information-seeking skills ($r = .321$, $p < .001$), problem-solving skills ($r = .538$, $p < .001$), collecting data ($r = .533$, $p < .001$), analyzing findings ($r = .686$, $p < .001$), writing skills ($r = .635$, $p < .001$), and communication skills ($r = .708$, $p < .001$). These findings underscore the importance of proficiency in research skills for enhancing statistical productivity among graduate students.

Furthermore, significant positive correlations were observed between statistical knowledge and productivity, with mastery of statistical concepts ($r = .824$, $p < .001$), applying statistical methods ($r = .792$, $p < .001$), interpreting statistical results ($r = .833$, $p < .001$), and drawing conclusions from statistical analysis ($r = .850$, $p < .001$) all showing strong associations. These results highlight the critical role of solid foundational knowledge and skills in statistics in fostering increased productivity in statistical tasks among graduate students.

Building on this, recent technological advancements offer promising avenues to further support students' statistical learning. In particular, Artificial Intelligence (AI) can significantly enhance students' statistical knowledge and productivity in various ways. AI-powered tools assist in statistical analysis by automating tasks such as data processing, visualisation, and interpretation, allowing students to focus more on understanding statistical concepts rather than performing manual computations (Cisirraamos et al., 2023). Additionally, AI-driven platforms offer automated grading and immediate feedback on statistical assignments, promoting student engagement and enabling timely identification of areas for improvement (Dhara et al., 2022).

AI also facilitates personalised learning experiences by tailoring statistical learning materials and exercises to individual student needs and proficiency levels, ensuring more effective learning outcomes (García-Martínez et al., 2023). Furthermore, AI can predict students' performance in statistical courses based on their learning behaviours, helping educators intervene early to provide the necessary support (Pacheco-Mendoza et al., 2023). Overall, AI aids in crafting engaging and personalised learning experiences like research and statistical productivity (Salas-Pilco et al., 2022), empowering students with efficient tools, personalised learning experiences, and predictive insights, ultimately enhancing their statistical knowledge and productivity.

Given these findings, concerned personnel, including educators, administrators, and policymakers, are urged to prioritise the integration of AI education, research skills training, and statistical knowledge development into graduate curricula. This approach can effectively enhance students' productivity and readiness for research and professional endeavours. Additionally, targeted support and resources should be provided to foster proficiency in AI adoption, research skills, and statistical knowledge among graduate students, thereby promoting their academic and professional success.

Furthermore, promoting interdisciplinary collaboration and exchange can facilitate the synergistic integration of AI, research skills, and statistical knowledge in graduate education and research initiatives. Implementing evidence-based strategies and interventions to address any disparities or challenges in AI adoption, research skills development, and statistical knowledge acquisition among graduate students is crucial for ensuring equitable access and opportunities for all learners. Thus, workshops, seminars, and training programs focused on AI adoption, research skills enhancement, and statistical knowledge development, alongside mentorship opportunities and collaborative research projects, can effectively support graduate students in maximising their productivity and success in their academic and professional pursuits.

The significance of big data analytics-powered artificial intelligence (AI) has grown in recent years, enhancing supply chain performance and other industrial sectors (Bag et al., 2021). AI adoption is intricately linked to statistical productivity, offering tools to increase productivity

levels within firms and drive overall efficiency across various industries. Studies show positive associations between AI usage and firm productivity, indicating that AI methods integrated into business processes can lead to labour cost savings, productivity improvements, and substantial macroeconomic effects (Hatzius, 2023). Systematic data on AI adoption and use is essential to understand its economic and societal impacts and to craft appropriate responses (Seamans & Raj, 2018).

The integration of research skills and statistical knowledge is crucial in various contexts, including academia and professional settings (National Academies of Sciences et al., 2018). Research skills, such as organising, evaluating, and extracting relevant information, are fundamental for conducting high-quality research and making informed decisions. By honing statistical analysis skills, individuals can effectively distil meaningful insights from vast datasets, enabling more informed decision-making and enhancing productivity (Feldon et al., 2011). The integration of research skills and statistical knowledge empowers individuals to navigate complex research processes, interpret data accurately, and contribute meaningfully to productivity and success in academic and professional environments. This combination is vital for leveraging the potential of AI, which can automate and enhance statistical tasks, ultimately driving both individual and organisational growth in an increasingly data-driven world.

These significant findings emphasise the interconnectedness between AI adoption, research skills, statistical knowledge, and statistical productivity among graduate students. Educators, administrators, and policymakers may recognize and leverage these associations to enhance graduate education and research initiatives. Activities such as integrating AI education, providing targeted support for research skill development, and strengthening statistical knowledge can be instrumental in fostering increased productivity and success among graduate students in their academic and professional pursuits. Additionally, promoting interdisciplinary collaboration and evidence-based interventions can further enhance productivity and ensure equitable access to opportunities for all learners in graduate education.

F. Predictors of Statistical Proficiency Among Students

Table 6 presents the predictors of statistical proficiency among students. Each predictor is accompanied by its coefficient (β), standard error of the coefficient (SE Coef), t-value, and associated p-value, providing insights into the strength and significance of their relationships with statistical proficiency.

Table 6 Predictors of Statistical Productivity Among Students

Predictors	Coef (β)	SE Coef	t- value	p-value
(Constant)	.324	.227	1.427	.156
AI Engagement and Participation	.279	.063	4.447	<.001
AI Integration in Research	.281	.076	3.680	<.001
Drawing Conclusions from Statistical Analysis	.556	.099	5.625	<.001
Mastery of Statistical Concepts	.317	.098	3.234	.002
Adjusted	80.40%			
F value	96.436			
P-value	<.001f			

Statistical Productivity=.324+.279* AI Engagement and Participation+.281* AI Integration in Research +.556* Drawing Conclusions from Statistical Analysis+.317* Mastery of Statistical Concepts

Among the predictors identified, "Drawing Conclusions from Data" demonstrates a significant positive relationship with statistical proficiency (β = .556, p < .001). This finding suggests

that the ability to interpret and draw conclusions from statistical analyses is a strong predictor of higher levels of statistical proficiency among students. Similarly, "Mastery of Statistical Concepts" exhibits a significant positive relationship with statistical proficiency ($\beta = .317$, $p = .002$), indicating that a solid understanding of statistical principles contributes meaningfully to improved performance in statistical tasks.

Furthermore, "AI Engagement and Participation" ($\beta = .279$, $p < .001$) and "AI Integration in Research" ($\beta = .281$, $p < .001$) both demonstrate significant positive relationships with statistical proficiency. This implies that active involvement in AI-related activities and the incorporation of AI methodologies into research practices are associated with higher levels of statistical proficiency among students.

The adjusted R-squared value of 80.40% indicates that approximately 80.4% of the variance in students' statistical proficiency can be explained by the predictors included in the model. Moreover, the highly significant F-value of 96.436 ($p < .001$) suggests that the overall regression model provides a strong fit to the data.

In summary, the regression equation for predicting statistical proficiency among students is as follows:

> **Statistical Proficiency** = 0.324 + 0.556(Drawing Conclusions from Data) + 0.317(Mastery of Statistical Concepts) + 0.279(AI Engagement and Participation) + 0.281(AI Integration in Research).

These findings offer valuable insights for educators and administrators in designing targeted interventions to enhance statistical proficiency. Emphasising the development of statistical understanding alongside active engagement with AI methodologies in research may foster more effective learning outcomes and research competencies among graduate students.

The integration of AI in research processes significantly enhances students' statistical productivity by automating routine tasks, minimizing errors, and extracting meaningful insights from large datasets. AI-powered tools enable students to conduct high-quality research and analysis, which is crucial for informed policy decisions and improving academic outcomes (Priyadarshini et al., 2022). As AI continues to evolve, its engagement in research and education plays a central role in boosting productivity across various sectors, particularly in academic environments (Productivity Commission, 2024).

For graduate students, incorporating AI into research workflows offers several benefits, such as access to virtual assistants that support productivity and reduce procrastination (Sabharwal et al., 2023). AI applications in online higher education—ranging from predicting performance and satisfaction to recommending resources and automating assessments—further exemplify how AI enhances the learning experience and overall academic outcomes (Ouyang et al., 2022). This integration of AI into educational and research activities is vital for enhancing students' research capabilities and overall productivity.

Mastery of statistical concepts and the ability to effectively interpret statistical analysis are strong predictors of students' research productivity. These skills enable students to navigate complex research data, generate accurate results, and produce insightful conclusions. By refining these competencies, students improve their ability to perform high-quality research, an essential skill for academic success and professional development (Feldon, 2011).

Graduate programmes that prioritise statistical education and offer opportunities for hands-on experience in data analysis play a vital role in cultivating essential research skills. Workshops, formal coursework, and mentorship from experienced researchers further enhance students' proficiency in statistical methods. As students gain confidence and competence in using statistical tools and techniques, their ability to conduct independent, high-quality research improves, thereby increasing their productivity and contributing meaningfully to their academic and professional fields (Al-Alem & Badarneh, 2021).

Building upon this foundation, mastery of statistical concepts and the capacity to draw

sound conclusions from statistical analyses emerge as key drivers of students' statistical productivity. These core competencies enable students to engage in rigorous, evidence-based research and equip them to address complex problems in both academic and applied settings. Therefore, developing these skills through targeted educational programmes and experiential learning is essential to preparing a new generation of capable and innovative researchers.

To support this objective, faculty members and graduate programme coordinators can implement a range of initiatives. Organising workshops and training sessions focused on data interpretation and the application of statistical methods can reinforce theoretical understanding through practical application. Offering advanced courses in statistical techniques, coupled with access to relevant software and tools, ensures students receive comprehensive, hands-on training. Moreover, promoting AI engagement through student clubs, faculty-led events, and interdisciplinary research projects facilitates the integration of AI into students' methodological toolkits.

In addition, mentorship programmes, coordinated by academic staff and mentorship coordinators, should match students with experts in statistics and AI to foster personalised learning and professional growth. Career services and faculty members can also provide continuous learning opportunities through seminars and industry partnerships, ensuring that students remain up to date with the evolving demands of research and data-driven professions. Collectively, these efforts will significantly enhance students' statistical competencies and better prepare them for successful, research-intensive careers.

CONCLUSION

The findings of this study demonstrate that the adoption of Artificial Intelligence (AI), coupled with strong research skills and sound statistical knowledge, significantly influences graduate students' statistical productivity. High levels of AI adoption reflect students' preparedness to integrate emerging technologies into academic and research contexts. Furthermore, well-developed research skills enable students to design and execute comprehensive studies, while statistical knowledge enhances their capacity to analyse data effectively. Despite this, the study also highlights a need for more targeted support in promoting productivity in statistical research specifically. The positive correlations among these variables underscore the importance of their integration in academic training to optimise research outcomes.

To address these needs, graduate programmes should incorporate AI education through workshops and practical training, expand support for the development of research competencies, and enhance statistical instruction with applied software-based learning. Faculty should also encourage interdisciplinary collaboration and embed statistical research methods within the curriculum to foster greater student engagement and productivity. Establishing dedicated research centres equipped with AI and statistical tools would further strengthen research capabilities. Students are encouraged to participate in AI-related activities, sharpen their methodological skills, and pursue collaborative research opportunities. Future studies may explore how these variables continue to evolve, offering a broader understanding of AI's impact on educational achievement. Collectively, these measures aim to enrich graduate education and foster innovation within an increasingly AI-driven academic landscape.

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