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Editor's Note

Dear All,

University transformation is not unexpected because higher education institutions are constantly evolving to adapt to societal and technological changes.

The Editor's Note of the APHEIT Journal of December issue 2024 shared with you about the Modern University in the nineteenth century based on the little book prepared by Margaret Clapp, published by Cornell University Press in 1950. In the 19th century, universities underwent significant transformations influenced by political, economic, cultural, and scientific changes. The traditional roles of universities primarily served as institutions for educating the elite, often rooted in religious or classical education. The curriculum focused on classical studies (Greek, Latin, philosophy, and theology), with limited attention to the practical or scientific discipline.

In the 20th century, universities continued to evolve, responding to dramatic social, political, economic, and technological changes, the debates between preserving traditional liberal arts education and emphasizing professional, technical, or scientific fields. Computers, the internet, and online learning platforms began to transform education delivery by the late 20th century. By the end of the 20th century, universities had solidified their roles as dynamic institutions integral to scientific progress, societal development, and cultural transformation. They became both mirrors and drivers of the complexities of the modern world.

Universities in the 21st century face numerous challenges as they adapt to a rapidly changing world. These challenges stem from shifts in societal, technological, economic, and political landscapes, as well as evolving expectations from students, employers, and governments.

Universities in the AI Era

The coming of artificial intelligence has disrupted traditional paradigms, requiring universities to adapt swiftly. In the AI Era, universities assume dynamic roles that reflect the noticeable influence of AI on every aspect of human life. The expectation of university roles include:

- *AI-driven education and research*: Universities are now at the forefront of developing AI technologies, exploring machine learning, neural networks, and data science. Programs increasingly integrate AI literacy as a fundamental skill alongside traditional disciplines.
- *Ethical and societal leadership:* As AI raises questions around bias, privacy, and autonomy, universities serve as ethical stewards, guiding the development of regulations and frameworks for responsible AI use.
- *Workforce readiness for AI:* Institutions tailor curricula to prepare students for careers in AI-related fields, emphasizing adaptability and lifelong learning to meet rapid technological changes.
- *Interdisciplinary innovation:* AI's impact spans healthcare, agriculture, finance, and the arts. Universities foster interdisciplinary collaboration, bridging gaps between fields to address complex societal challenges.
- Global AI cooperation: Universities act as hubs for international collaboration, ensuring that AI advancements benefit all regions equitably rather than deepening divides.

Universities in the AI Era reflect an evolution toward dynamic adaptability and innovation. The shift emphasizes speed, ethics, and interdisciplinarity, driven by the transformative power of AI.

University significance in the AI Era lies in their ability to anticipate and address the profound implications of a technology-driven world. By blending traditional strengths with forward-looking strategies, universities shall continue to solidify their place as invaluable institutions in an ever-changing world.

I do hope you still find the teaching profession in higher education institutions rewarding and challenging.

APHEIT journal is a platform for Share and Learn. We value your contributions.

Wish you all the best,
Manit Boonprasert, Ed.D
The Association of Private Higher Education Institutions of Thailand
Under the Patronage of Her Royal Highness Princess Maha Chakri Sirindhorn
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Digital transformation of educational management of art major in vocational colleges in Guangdong Province

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ABSTRACT

The objectives were to study the digital transformation of educational management and to propose guidelines for implementing digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province by employing a mixed-method research design. Using Krejcie and Morgan's table and simple random sampling, a sample of 317 teachers out of 1,782 population was selected. In-depth interviews were conducted with 9 administrators and 27 students. Nine experts were purposively selected for the focus group discussion to validate the proposed guidelines. Data collection included a 5-point rating scale questionnaire, an in-depth interview and focus group, using descriptive statistics and content analysis to analyze data. The study revealed that 1) the digital transformation in the educational management of art major included three components: teacher, teaching, and student management; and 2) the guidelines for implementing digital transformation for *teacher management*, are to reducing administrative centralization and authority as a guiding principle, with goals including the development of digital tools and infrastructure, the establishment of a multifunctional digital platform, and the promotion of data-informed decision-making in educational management. Regarding *teaching management*, enhancing teaching practices and acknowledging the strategic importance of digital transformation, with the development of blended teaching models and improved incentive and professional development mechanisms. In *student management*, improving the learning experience and outcomes was identified as a core value, with fairness, transparency, and the development of a personalized talent cultivation system recognized as key goals.

Keywords: Digital Transformation, Educational Management, Art Major, Vocational Colleges

Introduction

The China Education Informatization 2.0 Action Plan issued by the Ministry of Education (2021) highlighted that education informatization should serve as an endogenous force in the systemic reform of education, driving the modernization of education through updated concepts, model innovation, and system reconstruction. Similarly, the Action Plan for Improving the Quality and Training of Vocational Education (2020–2023) called for the digital transformation of vocational education management to enable the integration of information and intelligent technologies across all aspects of institutional administration, thereby significantly enhancing the precision and scientific basis of decision-making processes (Ministry of Education of China, 2020). In this context, the practical challenges and urgent needs faced by education decision-makers in vocational colleges—especially within art education—serve as a crucial foundation for this study. Digital transformation is particularly relevant to the field of art education in vocational colleges due to its potential to optimize educational management processes, improve instructional quality, and personalize learning experiences. Research has shown that digital platforms can facilitate more responsive and flexible administrative systems, which is essential for managing the creative and individualized nature of art education (Huang & Li, 2021). Moreover, art majors require innovative learning environments that support visual, interactive, and practice-based instruction, all of which are enhanced through digital technologies (Chen, 2022; Li & Wang, 2023). Analyzing and addressing the current status and constraints of digital transformation in the educational management of art design majors in Guangdong Province thus carries significant theoretical and practical value.

A comprehensive understanding of the digital transformation process requires examining the core elements that shape it. According to Ning, Liu, and Su (2022), digital transformation in education is characterized by the incorporation of new elements such as data intervention and digital empowerment. In higher education, these transformations manifest across three main dimensions: changes in educational models, talent cultivation, and curriculum reform. Zhang Qingshan (2022) further argued that the reform of vocational education under digital empowerment leads to significant shifts in learning methods, the redefinition of teacher roles, and new approaches to assessment. Based on these insights, this study categorized the management aspects of digital transformation into three areas: student management, teacher management, and teaching management.

In the domain of student management, digital tools can address the specific needs of art students by offering personalized services and monitoring

progress in creative fields. For example, Tang (2017) noted that art design students in vocational colleges exhibit unique administrative challenges that can be addressed through digital transformation. Wang (2018) proposed dividing student management into three dimensions—student services, student education, and student discipline—each of which can benefit from digital systems that enhance efficiency and communication.

In terms of teacher management, Yao (2020) identified three major components—teacher training and development, evaluation systems, and participation in educational governance—all of which can be enhanced through digital platforms. These tools not only streamline performance evaluations and training programs but also promote collaboration and transparency. Moreover, studies have emphasized that the digital literacy of administrators plays a pivotal role in successfully implementing teaching management reforms (Liu & Pan, 2022). Enhanced digital competency among education managers leads to data-informed decision-making and the development of platforms tailored to the specific needs of creative disciplines.

To conclude, this study aims to explore the components of digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province and to proposed guidelines for implementing digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province. The goal is to provide decision-makers with a clear framework for transformation, enabling them to harness existing institutional strengths and overcome implementation challenges. By addressing management issues through digital innovation, vocational colleges can enhance the effectiveness, flexibility, and relevance of art education in an increasingly digital world.

Purposes

1. To study the digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province

2. To proposed guidelines for implementing digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province

Research Process

Step 1: Conduct a comprehensive literature review and analyze related research to examine policies and the current status of digital transformation in the educational management of art majors in vocational colleges in Guangdong Province.

Step 2: Develop semi-structured interview questions based on an analysis of the key components of digital transformation in educational management, categorized into three domains: student management, teacher management, and teaching management.

Step 3: Conduct in-depth interviews with nine key informants, selected through purposive sampling. These informants

included 9 administrators and 27 students involved in art programs from three vocational colleges in Guangdong Province.

Population, Sample, and key informants

The population consisted of 1,782 teachers from three vocational colleges in Guangdong Province. Using Krejcie and Morgan (1970) and simple random sampling, a sample of 317 teachers was selected. In-depth interviews were conducted with 9 administrators and 27 students. Additionally, 9 experts for focus group discussion.

Instruments and Data Collection

This study employed a mixed-methods approach for data collection. A structured questionnaire was developed to assess the current level of digital transformation across three key domains of educational management: student management, teacher management, and teaching management. The questionnaire utilized a 5-point rating scale and was analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation.

In addition, in-depth interviews were conducted with nine administrators and twenty-seven students from vocational colleges offering art programs. The qualitative data obtained were analyzed using content analysis to extract key themes and insights. Based on the findings from both quantitative and qualitative data, a set of practical guidelines for the digital transformation of educational management in art majors was proposed.

To ensure the validity and applicability of the proposed guidelines, expert validation was conducted. Nine experts in the fields of educational management, digital transformation, and vocational education were selected through purposive sampling to review and provide feedback on the guidelines.

Conclusion and discussion

Conclusion

1. Digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province**.**

1.1 The analysis of policies and the current situation reveals that digital transformation in the educational management of art majors in vocational colleges in Guangdong Province is strongly supported. Key policies include: (1) the Opinions on Promoting the High-Quality Development of Modern Vocational Education, which emphasizes the integration of digital technology to modernize vocational education systems (State Council of China, 2021); and (2) at the provincial level, the Three-Year Action Plan for Vocational Education Expansion, Quality Improvement, and Strong Service (2019–2021) and the 2023 Funding Arrangement Program both highlight digital infrastructure and smart management systems as essential tools for administrative reform (Guangdong Provincial Government, 2019; Guangdong

Provincial Department of Education, 2022).

1.2 Analysis of the current situation of digital transformation of education management of art major in vocational colleges in Guangdong Province from literature reviews, interview, and questionnaire result with digital technology in the context of three key domains of educational management: student management, teacher management, and teaching management. The result as below:

Questionnaire result show that the sample of teachers (n=317) consists of a nearly equal gender distribution (49% male, 51% female). Most participants are aged 40 or above (53%), with 55% holding an undergraduate degree and 21% holding a postgraduate degree or higher. The majority have over three years of teaching experience (62%), and 98% hold positions as teachers or administrative staff, while only 2% are principals or deans.

1.2.1 Student management

The analysis of student management in higher vocational colleges in Guangdong Province, based on 11 questions, shows an overall high level of satisfaction (mean scores between 3.719 and 3.852). The three highest-rated items are: Q(5) – inclusion of skill-based content in online teaching for art majors ($\bar{x}$=3.852, SD=1.122), which effectively boosts student engagement; Q(9) – recognition of unique traits among art design students, such as active thinking and emotional sensitivity ($\bar{x}$=3.839, SD=1.157); and Q(7) – the positive impact of interactive online classrooms on student satisfaction and support for online teaching ($\bar{x}$=3.839, SD=1.123). The lowest-rated item is Q(6) ($\bar{x}$=3.719, SD=1.153), which suggests that while students prefer recorded/live teaching over static materials, there is still room for improvement in teaching technologies. These findings reflect that the digital transformation in student management is generally effective, particularly in content relevance and student-centered approaches, but technical aspects of online delivery still require enhancement.

The interview results support the findings from the questionnaire, indicating that while the overall efficiency of education management in higher vocational colleges in Guangdong Province is high, the level of student services remains relatively low, with noticeable shortcomings in certain application functions such as information access and online administrative procedures. Teachers generally acknowledge and support the rapid advancement of online teaching driven by digital transformation, aligning with the high satisfaction ratings in the questionnaire. However, both sources emphasize the urgent need to further develop and improve high-quality educational resources, both online and offline, to enhance teaching effectiveness. Additionally, the interviews confirm that students majoring in art design possess distinct personal and learning characteristics, which require tailored educational strategies. Lastly, while digital tools have improved management

efficiency, concerns remain regarding the fairness and equity of education management systems, indicating a need for more balanced and transparent mechanisms.

1.2.2 Teacher management

The analysis of teacher management in higher vocational colleges in Guangdong Province, based on nine questions, shows consistently high satisfaction across all aspects, with mean scores ranging from 3.733 to 3.909. The three highest-rated items are: Q(14) – establishing links with enterprises to provide practical experience and digital skills training for teachers ($\bar{x}$=3.909, SD=1.111), Q(17) – use of scientific, quantifiable standards to evaluate teachers' professional ability and ethics ($\bar{x}$=3.849, SD=1.112), and Q(20) – scientific and reasonable management of online teaching during COVID-19, especially for practical courses ($\bar{x}$=3.814, SD=1.111). These results reflect strong support for professional development, fair evaluation, and adaptive online teaching management. However, the lowest-rated item is Q(19) ($\bar{x}$=3.744, SD=1.077), indicating a lack of sufficient teacher participation in policy-making processes such as allowance systems and management rules. This suggests that while the digital transformation has enhanced training and evaluation practices, it still needs to address systemic issues in governance and inclusivity, particularly by ensuring that teachers have a stronger voice in decision-making.

The interview findings reinforce the questionnaire results on teacher management in higher vocational colleges in Guangdong Province. There is strong policy and financial support for teacher training and capacity building, and school-enterprise cooperation has been effectively implemented—consistent with the high rating of Q(14), which highlights practical training opportunities. However, teachers express anxiety about their digital competencies, aligning with the need for continued professional development noted in Q(13). While teachers largely acknowledge the fairness and scientific basis of evaluation systems (supporting Q(16) and Q(17)), the usability of digital tools like campus OA is still lacking (reflecting the lower rating in Q(15)). Additionally, teachers feel that their participation in educational decision-making is limited and not actively encouraged, which supports the relatively lower rating of Q(19) and underscores the need for more inclusive governance in the digital transformation process.

1.2.3 *Teaching management*

The analysis of teaching management based on 11 questions reveals a consistently high level of satisfaction among teachers in higher vocational colleges in Guangdong Province, with mean scores ranging from 3.697 to 3.886. The three highest-rated items are: Q(28) – the ability of digital transformation tools (e.g., Tencent Conference, online teaching models) to significantly change teaching methods and enhance teaching

effectiveness ($\bar{x}$=3.886, SD=1.116), Q(21) – supportive education policies and administrative measures for promoting digital transformation in vocational education ($\bar{x}$=3.845, SD=1.119), and Q(31) – teachers' preference for recording and live broadcast methods over static teaching material distribution ($\bar{x}$=3.845, SD=1.155). These results suggest strong policy support, technological adaptability, and teacher recognition of digital tools' impact on pedagogical quality. However, the lowest-rated item is Q(27) ($\bar{x}$=3.697, SD=1.160), indicating that despite the growing integration of digital applications like OA systems and online platforms, the overall user experience remains suboptimal. This points to a need for improving the usability and effectiveness of existing digital teaching tools to ensure smoother implementation and higher satisfaction among educators.

The interview findings align with the questionnaire results on teaching management in higher vocational colleges in Guangdong Province. While education policies and financial support are generally fair—supporting Q(21) which shows high recognition of policy effectiveness—there is a clear gap in the attention and investment toward building high-quality educational resources, echoing the lower satisfaction in Q(25) regarding the integration of current industrial digital technologies into teaching content. Additionally, although managers demonstrate scientific decision-making ability, consistent with the high scores in Q(30) and Q(31), the lag in digital campus infrastructure, inconvenient system usage, and missing functions—reflected in the lowest-rated item Q(27)—highlight ongoing challenges in digital application usability. These results emphasize the need to strengthen digital infrastructure and prioritize the development of accessible, comprehensive teaching tools to fully realize the benefits of digital transformation.

2. Guidelines for implementing digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province

Focus group discussion from nine experts to conclusion in the digital transformation of educational management for art design majors in Guangdong's higher vocational colleges should follow a clear and practical set of guidelines that reflect both policy direction and institutional realities:

(1) Overall Goal: To cultivate talent that aligns with the evolving digital economy and society; ensure that teachers acquire essential digital skills and literacy; and reconstruct the development path and strategic thinking of vocational education in the digital age.

(2) Action Plan: Highlight the unique characteristics of vocational art education; strengthen digital literacy among administrators; promote innovation in institutional structures to bridge digital capability gaps; and encourage government support for building a modern vocational education system.

(3) Policy Support: The Guangdong provincial government should explore

region-specific digital transformation models in vocational education, aiming to construct a high-quality, modern vocational education system. This includes supporting pilot programs for a multi-tiered education pathway encompassing vocational undergraduate, master's degree, and doctoral levels.

(4) Guiding Principles: Ground actions in real-world institutional contexts; implement change in stages; ensure coordination across multiple stakeholders; strengthen professional development and training; and apply scientific, system-level planning approaches.

(5) Specific Objectives: Accelerate the development of new educational infrastructure; establish personalized and flexible talent training models; promote the integration of hybrid (online and offline) teaching; build digital talent training bases; and incorporate industry product, technical, and service standards into vocational qualification certification frameworks.

Building upon the model and the nine-dimensional framework of educational digital transformation, the following focus areas are emphasized:

(1) Student Management: Improving the learning experience and outcomes for students should be a central objective. Justice and transparency must be the core principles, with the creation of a personalized, student-centered talent development system as the key implementation goal.

(2) Teacher Management: Enhancing teaching methods and elevating the strategic role of digital transformation are essential. Fairness and openness remain the primary values, while developing hybrid teaching models and strengthening teacher training and incentive systems are the practical goals.

(3) Teaching Management: De-administration and decentralization should guide reform. Specific aims include the development of robust digital tools and multifunctional platforms to support decision-making. Principles such as scientific planning, cost-effective governance, data-driven management, and phased, needs-based implementation should shape the reform trajectory.

Digital Transformation Framework for Educational Management in Art Majors at Vocational Colleges to implementation as Figure below:

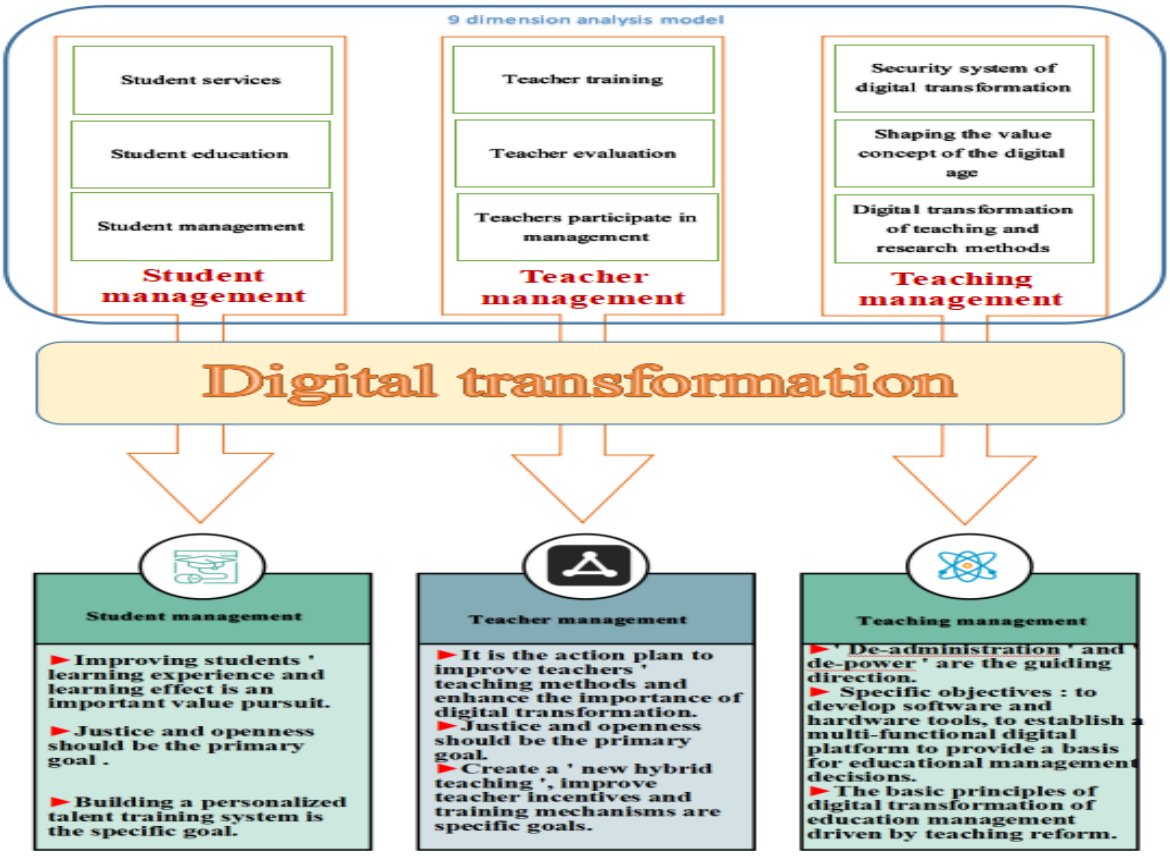

Figure 1: Digital Transformation Framework for Educational Management in Art Majors at Vocational Colleges

Discussion

1. The digital transformation of educational management of Art Major in Vocational Colleges in Guangdong Province

The results indicate that the digital transformation of educational management in art majors at vocational colleges in Guangdong Province is progressing steadily, with policy support and practical implementation in place. However, several systemic challenges remain, particularly in resource allocation, platform usability, and stakeholder participation.

1.1 Student Management. The findings demonstrate that digital tools significantly enhance student engagement, particularly through skill-oriented and interactive teaching formats. This supports previous studies that emphasize how digital learning environments can foster motivation and personalized learning pathways for vocational students (Zhao & Liu, 2020; Sun et al., 2021). However, technical shortcomings and inequities in service delivery, such as inadequate administrative digital services and lack of fairness in access, mirror concerns raised by Huang (2022), who highlights the digital divide in education services in underdeveloped areas. Tailored approaches for students with unique learning profiles—such as those in art and design—are essential for inclusive

educational governance (Geng et al., 2021).

1.2 Teacher Management. Survey and interview results show strong institutional support for teacher development through school-enterprise cooperation and fair evaluation systems, aligning with the conclusions of Chen et al. (2020), who argue that real-world practice integration is key to digital readiness among vocational educators. Nevertheless, issues such as digital anxiety and low involvement in policy-making reflect broader structural governance gaps, which Wu and Zhang (2021) identify as barriers to empowering teachers during digital reforms. The underperformance of campus OA systems, noted both in question no.15 and interview comments, underscores the finding by Li and Shen (2023) that technological design flaws hinder the adoption of digital administration systems in vocational institutions.

2. Teaching Management. The teaching management domain reflects high satisfaction with digital tools' impact on pedagogy, consistent with the research of Wang and Huang (2021), who found that hybrid teaching and interactive platforms increase teacher efficacy. The high recognition of favorable policy environments was also consistent with national initiatives outlined by the Ministry of Education (MOE, 2021), promoting the integration of smart education systems. However, the relatively low score reflects frustrations with digital system usability, echoing concerns raised by Tang and Yuan (2020), who argue that superficial digital infrastructure without functional support impedes transformation success.

3. Guidelines for Implementing Digital Transformation in Educational Management of Art Majors in Vocational Colleges

The development of a structured, actionable guideline for digital transformation in educational management among art majors in Guangdong's vocational colleges aligns with both national policy direction and institutional necessities. The focus group conclusions clearly emphasize the importance of cultivating digital talent, advancing educational infrastructure, and ensuring fairness and inclusivity across student, teacher, and teaching management domains.

In *student management*, the guidelines stress creating a personalized, student-centered talent development system rooted in justice and transparency. This is supported by Sun, Zhang, and Liu (2021), who found that digital learning environments can significantly improve engagement when tailored to students' cognitive and emotional traits—particularly relevant for art students who often exhibit high levels of creativity and emotional sensitivity. Additionally, Geng, Wang, and Li (2021) argue that personalized learning models are essential in vocational art education due to the diversity of learner profiles and professional outcomes. The current guidelines propose segment-based

implementation and phased planning to ensure the practicality of reforms in enhancing students' digital learning experience and outcomes.

Regarding *teacher management*, the focus is on improving digital literacy, hybrid teaching capability, and fair evaluation systems. Chen, Liu, and Xu (2020) emphasize that vocational colleges must embed digital skills training into continuous professional development to overcome teachers' anxiety about technological competence. This aligns with findings in the present study that call for increased support in digital upskilling and innovation-driven organizational, Wang and Huang (2021) highlight that blended teaching models are highly effective in vocational settings, where practical and theoretical learning must coexist. However, Wu and Zhang (2021) stress that teacher participation in institutional governance remains limited during digital reforms—a concern reflected in this study and addressed in the guideline through the call for inclusive decision-making mechanisms and strengthened incentive systems.

In the domain of *teaching management*, the guidelines advocate for decentralization, integration of industry standards into teaching, and the development of multifunctional digital platforms to inform decision-making. Tang and Yuan (2020) argue that educational digital transformation must be driven by the dual pillars of infrastructure readiness and managerial innovation. While digital tools like online platforms and campus OA are increasingly adopted, Li and Shen (2023) note that usability and system integration issues remain barriers to optimal use—highlighting the need for user-centered platform design, as also underscored in the present research. Moreover, Zhao and Liu (2020) affirm that aligning vocational education with real-world industry standards—both in content and certification—is essential for bridging the education-to-employment gap, a principle clearly embedded in the guideline's proposed framework.

Collectively, these guidelines represent a practical and research-informed blueprint for the digital transformation of educational management in vocational art programs. By anchoring reform efforts in systemic planning, policy alignment, and real institutional needs—as also emphasized by the Ministry of Education (2021)—this approach supports sustainable, scalable, and inclusive innovation in vocational education.

Recommendation

1. Recommendation for policy level

1.1 Develop region-specific digital transformation policies that address the unique needs of vocational art education.

1.2 Increase provincial investment in digital infrastructure and high-quality educational resources.

1.3 Mandate teacher participation in institutional governance to improve fairness in management decisions.

1.4 Integrate industry certification standards into vocational education policy frameworks.

1.5 Support multi-tier vocational education(undergraduate–doctoral) through national and provincial pilot programs.

2. Recommendation for practical applications

2.1 Enhance the usability and functionality of digital platforms (e.g., OA systems) for teaching and communication.

2.2 Provide continuous digital training for teachers and administrative staff to close capability gaps.

2.3 Establish hybrid teaching models that blend online interactivity with hands-on instruction.

2.4 Strengthen mechanisms for teacher feedback and participation in rule-making and performance evaluation.

2.5 Use data-driven decision-making tools to support transparent and responsive education governance.

3. Recommendations for future research

3.1 Explore the impact of digital transformation on student learning outcomes across various art disciplines.

3.2 Investigate the long-term effectiveness of hybrid teaching models in vocational colleges.

3.3 Examine how institutional culture affects the success of digital governance in educational management.

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Educational management guidelines in Art Universities under Liaoning Province

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ABSTRACT

The objectives were 1) to study the current situation of art universities management and 2) to propose educational management guidelines for art universities in Liaoning Province, employing a mixed-method approach. The population of 1,992 teachers working during the 2022 academic year was drawn from the Lu Xun Academy of Fine Arts and the Shenyang Conservatory of Music. The sample was 322 teachers using Krejcie and Morgan's table, obtained through a simple random sampling. Fifteen key informants were selected through purposive sampling for in-depth interviews and 7 experts for focus group discussions to verify the proposed guidelines. The data collection instruments included a questionnaire with a five-point rating scale and a guideline confirmation form. Data analysis were descriptive statistics and content analysis. The results revealed that 1) the current situation of art university management included guidelines establishment for overall regulation and formulation of guiding programs; creation of interdepartmental cooperation mechanisms; and maintenance of dynamic and appropriate educational policy formulation, and 2) educational management guidelines included strengthening teacher training to build high-quality teaching personnel, innovate teaching methods, cultivate a sense of responsibility among teachers, and enhance teacher leadership. Ensuring the perfection of technology platforms and digital infrastructure, establishing reasonable teaching evaluation and reward mechanisms, and developing dynamic and balanced educational policies which coordination should be multidimensional. A collaborative teacher network should be established to facilitate the active sharing of teaching experience, promote a harmonious teacher-student relationship.

Keywords: Educational Management, Art universities, Liaoning Province

Introduction

In 2020, the global outbreak of COVID-19 forced governments to re-evaluate the role of higher education, with a strong emphasis on online teaching, flexible learning systems, and student well-being (Zhou, Li, Wu, & Zhou, 2020). In China, the Ministry of Education responded by developing targeted policies, strengthening university governance, incentivizing educational innovation, and updating online teaching models to adapt to the digital era (Chen, et.al., 2021). As the education system transitions into the post-pandemic era, both teachers and students in art universities face significant challenges, especially in maintaining engagement, mental health, and effective teaching methods in online environments (Liu, Lin, Zhang, & Wang, 2022). Prior to the pandemic, the integration of information technology into education had already begun transforming pedagogical structures. This digital shift—accelerated by the pandemic—continues to redefine educational relationships, making information-based teaching an essential pathway for reform and modernization (Li & Yang, 2020).

The government has also placed greater emphasis on teacher training and educational quality assurance. As stated in the 2014 "Opinions on Deepening Educational Supervision Reform and Transforming Educational Management Mode," the state encouraged separating academic achievement from administrative assessment, promoting educational equity, and enhancing school management through systematic reforms (Ministry of Education of the People's Republic of China, 2014). Scholar Wang Zhuli emphasized the need for a new education and teaching system, shifting from rigid, content-based instruction to a more flexible, student-centered approach, focusing on soft skills and learning outcomes (Wang, 2020). In art universities, this transformation is particularly crucial, as students' learning is deeply influenced by creativity, emotional expression, and psychological stability. The pandemic intensified students' mental health concerns and disrupted traditional learning environments, necessitating a reevaluation of teaching models and management strategies (Zhang, Xu, & Song, 2021).

This research is therefore significant in addressing the educational needs of art universities in Liaoning Province during the post-pandemic transition. By analyzing students' psychological states, exploring artistic learning characteristics, and reconstructing teaching management frameworks, the study contributes to both theoretical and practical advancements. The development of educational management guidelines tailored to art universities not only helps improve teaching effectiveness but also

supports sustainable student development and educational modernization. The findings can inform policy-makers, academic leaders, and faculty members as they respond to the evolving demands of post-pandemic higher education.

Purposes

1. To study the current situation of art universities management in Liaoning Province

2. To propose educational management guidelines for art universities in Liaoning Province.

Benefit of Research

This research benefits art universities by providing practical guidelines to improve educational management in the post-pandemic era, supporting digital integration, student well-being, and teaching innovation, while aligning with national goals for education modernization.

Research Process

Step 1: Study literature review and related research to identify the factors of art universities management in Liaoning Province. Create questionnaire and question for interview.

Step 2: Analyze from data collection both Semi-structured interview and questionnaire.

Step 3: Content analysis from focus group discussion to propose and verify the guidelines.

Population and Sample

The population consisted of 1,992 teachers working during the 2022 academic year. The sample size was determined using Krejcie and Morgan's table and obtained through a simple random sampling method, resulting in 322 teachers. In addition, 15 key informants were selected through purposive sampling for in-depth interviews. Furthermore, seven experts were selected via purposive sampling to participate in focus group discussions to construct and verify the proposed guidelines.

Instruments

1. Interviews in semi-structure
2. Questionnaires
3. Focus group

Data analysis

Data collection included a questionnaire with a five-point rating scale. The statistical methods used for data analysis were frequency, percentage, mean, and Standard Deviation. The data from in-depth interviews and focus group discussions were analyzed using content analysis.

Conclusion and discussion

Conclusion

1. The current situation of art universities management in Liaoning Province

1. The basic information of the Educational Management Questionnaire for art universities in Liaoning Province was collected from a total of 322 teachers. Among the respondents, 167 were male (51.90%) and 155 were female (48.10%), indicating a relatively balanced gender distribution. In terms of age, the majority—229 teachers (71.10%)—were under the age of 45, while 93 teachers (28.90%) were aged 45 or older. Regarding educational background, 131 teachers (40.70%) held a bachelor's degree, and 191 teachers (59.30%) held a degree higher than a bachelor's. For teaching experience, 186 teachers (57.80%) had less than 15 years of experience, and 136 teachers (42.20%) had 15 years or more. Concerning professional titles, 73 teachers (22.70%) were assistant lecturers, 157 (48.80%) were lecturers, 90 (28.00%) were senior lecturers, and only 2 teachers (0.60%) held the position of full senior lecturer. This demographic distribution provides a comprehensive overview of the teaching workforce involved in the study and supports the diversity and representativeness of the data collected.

2. The current situation of platform learning management in art universities in Liaoning Province (n = 322) during the post-epidemic era was assessed across seven key indicators. The data reveal high levels of implementation in most areas, with the mean scores ($\bar{x}$) and standard deviations (S.D.) reflecting overall positive perceptions from respondents. The three highest-ranked items are: Item 6: "The period of epidemic era that the university set up the goals and plans to implementing in the teaching management" ($\bar{x}$ = 4.18, S.D. = 1.05) ranked 1st. This indicates that universities were highly proactive in setting clear goals and plans for teaching management during the epidemic. The relatively high mean and moderate standard deviation suggest strong consensus and effectiveness in this area. Item 3: "The period of epidemic era that the university prepared and trained teachers for online teaching" ($\bar{x}$ = 4.10, S.D. = 1.13) ranked 2nd. This reflects the universities' strong emphasis on capacity-building and ensuring that educators were equipped with the necessary skills for online instruction. And Item 7: "The period of epidemic era that the university derived and maintained in-depth cooperation with teaching platforms" ($\bar{x}$ = 4.05, S.D. = 1.07) ranked 3rd. This shows a high level of institutional collaboration with online teaching platforms, ensuring infrastructure and support for effective virtual learning.

In contrast, the lowest-ranked item is: Item 4: "The period of epidemic era that teachers had high ability in self-management evaluation in online teaching" ($\bar{x}$ = 3.35, S.D. = 1.18) ranked 7th, with only a medium level of implementation. This suggests that while universities supported online infrastructure and planning, teachers may have struggled with independently evaluating and managing

their teaching performance in virtual settings. The higher standard deviation also indicates varied experiences among respondents, reflecting inconsistencies in self-assessment capacity.

In summary, the findings show that art universities performed well in strategic planning, teacher training, and platform collaboration during the epidemic. However, there is a noticeable gap in individual teachers' self-management and evaluation skills, highlighting an area for improvement in future educational management development.

3. The findings show that the most important factor in improving educational management in art universities through educational leadership is the active provision of digital platforms with strong resources, capacity, and efficiency ($\bar{x}$ = 4.52, S.D. = 0.980), followed by the promotion of innovative tools for effective online assessment and learning outcome measurement ($\bar{x}$ = 4.45, S.D. = 0.944), and the creation of effective technology platforms and student service channels to support quality teaching management ($\bar{x}$ = 4.44, S.D. = 0.913). These top-ranked items reflect the crucial role of digital infrastructure and support systems in post-pandemic education. In contrast, the lowest-ranked item, though still rated highly, was the ability of teachers to adopt diverse online teaching methods to achieve learning outcomes ($\bar{x}$ = 4.39, S.D. = 1.071), indicating a need for further professional development and support to enhance teachers' digital competencies and instructional flexibility.

4. The researcher summarized the content obtained from the interviews, highlighting the top three themes based on frequency as follows: ***1) Curriculum:*** (1) Universities created content and curricula appropriate for online teaching within the teaching plans. (2) The current curriculum was considered reasonable during the epidemic period. (3) Universities implemented different strategies tailored to various types of professional courses during the epidemic era. ***2) Teaching Form (Teaching Style):*** (1) Teaching styles during the epidemic era focused on individual learning needs.(2) Teaching styles were able to support effective communication between teachers and students.(3) The teaching format allowed flexibility for future development and adaptation of best practices from traditional teaching. ***3) Interactive Method*****:** (1) Teachers designed interaction methods that met the needs of both teachers and students during the epidemic. (2) The interactive methods received positive feedback from students. (3) The approaches were sufficient to simulate hands-on learning experiences in the online environment**.** ***4) Assessment Methods*****:** (1) Evaluation methods during

the epidemic were adapted to be more scientifically rigorous. (2) Online evaluation methods were considered more effective than traditional approaches, (3) Appropriate evaluation tools and platforms were implemented for online teaching. **5) *Technical Skills*:** (1) Teachers' technical skills during the epidemic met the basic teaching requirements. (2) Classroom technology capacity was sufficient to meet management needs. (3) There was a recognized need for additional training to improve teachers' technical skills. ***6) Teaching Experience***: (1) Teachers with extensive experience positively influenced online teaching. (2) Varied teaching experience supported more effective online instruction. (3) Teaching experience was critical for classroom management in the online context. ***7) Training Situation***: (1) Universities provided relevant training courses for teachers in online teaching. (2) Institutions offered ongoing support for training related to digital education. (3) Necessary resources such as materials, platforms, and learning tools were provided to enhance online training opportunities. ***8) Student Acceptance***: (1) Students accepted the online teaching formats implemented by universities during the epidemic. (2) Students adapted to subjects, materials, tools, and online learning platforms. (3) Students reported satisfaction and understanding of the university's online teaching management. ***9) Learning Attitude***: (1) Students maintained a positive attitude toward learning. (2) University support services contributed to positive learning attitudes among both students and teachers. (3) Factors such as time, tools, and teaching format enhanced students' learning attitudes. ***10) Course Feedback:*** (1) Interactive teaching methods addressed both student and teacher needs, with successful learning outcomes reflected in course feedback. (2) Effective teaching methods improved the quality of feedback received. (3) Management mechanisms influenced the feedback and overall learning outcomes. ***11) Educational Resources:*** (1) Universities provided adequate technological platforms for online teaching during the epidemic. (2) Teaching resources were sufficient during the transition to online learning. (3) Innovative teaching resources were identified as necessary and should be further developed. ***12) Environmental Adaptability of Teaching Materials and Equipment***: (1) the quality of teaching materials played a crucial role in effective management. (2) Updating teaching materials to ensure quality and course relevance was essential. (3) Reliable internet connectivity significantly impacted the effectiveness of online teaching.

Comparing the content of literature review, relevant research and in-depth interviews, establish a new guideline for focus group discussion with 7 experts, as shown in Table 1

Table 1: Educational Management of Art Universities in Liaoning Province

Item	Content Analysis to draft guideline		
	Input	Process	Outcome
1. Literature review and related research	1 Teaching resources and teaching materials 2 Policy development for innovative educational strategies and methods 3 Policy for optimal class sizes and teacher training 4 Increase student acceptance and engagement 5 Technical equipment and hardware environment	1. Implement policies to broaden access to diverse and high-quality teaching resources 2. Strengthen the teaching environment via strategic initiatives 3. Formulate policies to expand professional development and training opportunities for educators and staff 4. Improve the feedback mechanism 5. Implement policies to improve technological infrastructure	1. Enhance resource capacity by resolving existing limitations 2.Forms of education adapted to the existing environment 3. Enhance teacher and student competencies through targeted policies 4. Implement policies to overcome current resource constraints 5.Improve the hardware environment
2.In-depth interviews (15administrators and teachers)	1 Educational Strategies and Methods 2 Develop policies to optimize class size and ensure adequate teacher training and development 3 Promote policies that foster student acceptance and active engagement in the	1. System and Mechanism Construction 2. Improve training opportunities 3. Promote the implementation of diverse feedback mechanisms through educational policy 4. Implement policies to regularly revise and	1. Improve the guidelines 2. Strengthening Teacher Capabilities 3. Develop policies to enhance stakeholder satisfaction in the educational environment 4. Promote policy support for the

	learning process 4 Teaching resources and teaching materials 5 Technical equipment and hardware environment	modernize teaching materials. 5. Upgrading and maintaining educational infrastructure and technology	integration of diversified learning and teaching resources 5. Ensure sustainable provision and maintenance of educational hardware
3.Focus group discussion with 7 experts	1 Educational Strategies and Methods 2 Class capacity and training 3 Student Acceptance and Engagement 4 Teaching resources and teaching materials 5 Technical equipment and hardware environment	1. Implement government policy support 2. Improve networking opportunities 3. Establish policies that promote the use of diverse feedback methods to enhance teaching and learning effectiveness 4. Incorporate new technologies 5. Enterprise intervention	1. Improve the efficiency of perfection 2. Improve teachers' vision and ability 3. Feedback results are more reliable 4. Teaching management has been strengthened through effective policy implementation 5. Improve hardware background reliability

2. Educational management guidelines for art universities in Liaoning Province

2.1 From Table 1. Summarize the content of literature review, relevant research and in-depth interviews, establish a new guideline for focus group discussion as below.

1) Promoting teacher-student cooperation and interaction shows that promoting teacher-student collaboration, interaction, integration, and enhancing communication received the highest recognition. In classrooms, teachers leverage mobile devices and applications to foster a participatory learning environment. Outside the classroom, students utilize mobile devices for mobile learning, overcoming spatial restrictions and maintaining interaction with teachers and peers to ensure teaching content is relevant and effective.

2) Online teaching at Lu Xun Academy of Fine Arts and Shenyang Conservatory of Music. Most interviewees agree that these institutions have implemented diverse strategies to maintain online teaching quality in the post-pandemic era. The dedication and

professionalism of teaching staff have been positively evaluated by students. These strategies include appropriate online teaching training, employing multiple platforms and tools, increasing student engagement, and providing support. However, some concerns were raised regarding limitations in educational resources and equipment, affecting the perceived reliability of online education. Continuous improvement is needed, particularly addressing resource and equipment challenges.

3) Impact of management factors on educational administration in Art Universities, interviewees emphasize the need for flexible management responses to the pandemic, including relevant policy formulation and quality assurance mechanisms. Specific recommendations include developing new education management models, providing online education and training, and prioritizing mental health support. Enhancing education management quality requires multifaceted approaches: policy development, system and mechanism establishment, and attention to the mental well-being of faculty and students.

4) Key factors affecting education management in art Universities' fifteen factors were evaluated for their influence on educational management. Teaching methods, technological competence, student acceptance, teaching experience, and training received the highest recognition. This underscores the critical role of online teaching formats and educational technology in managing art education post-pandemic. Additionally, student engagement and teacher professional development warrant focused attention.

5) Enhancing education management quality in art Universities suggestions to improve education management include establishing comprehensive online management systems, enhancing teachers' online teaching proficiency, increasing student acceptance, strengthening teaching resource development, and adopting innovative technologies. Improving education management quality requires integrated efforts across multiple domains.

6) Strengthening educational management in art Universities, interviewees highlight the need to reinforce technical infrastructure and hardware, educational strategies and methodologies, teacher capacity and training, student accessibility and engagement, and teaching resources. Effective improvement in education management necessitates balanced attention to both human and material resources.

7) Art Universities in Liaoning Province recommendations for include

developing clear online education guidelines, encouraging diverse online teaching methods, promoting innovative online assessments, focusing on teaching management and evaluation systems, and actively utilizing digital platforms to provide enhanced tools and learning resources. These guidelines offer valuable references for advancing education management quality in the region.

2.2 Guidelines for art universities in Liaoning Province from focus group discussion from seven experts as below.

1) Coping Strategies at the Macro Education System Level. The government established a full-time agency for overall planning and regulation and formulated guiding policies. To better address the epidemic's impact on teaching, the education department formed a dedicated epidemic response leading group responsible for policy formulation and implementation oversight. This team included diverse members such as education leaders, experts from various fields, communication technology specialists, parents, and student representatives. Responsibilities were clearly defined, and an open accountability mechanism was developed to help departments at all levels hold individuals or units accountable, thereby improving work efficiency. To ensure timely communication during the epidemic and to facilitate "suspending classes while continuing learning," the group formulated evidence-based guidelines. These guidelines covered macro-level education goals—such as students' right to education and basic online teaching conditions—and specific measures like teaching arrangements, student assessments, and examination schedules. The guidelines guided departments in creating specific action plans and optimizing resource allocation within limited timeframes.

A cross-departmental cooperation mechanism was established, pooling resources and efforts from multiple parties to enhance government functional departments' capacity. From the education system perspective, specific strategies were formulated according to actual conditions, such as school reopening timelines and online teaching resources. Following the national school closure directive, local education departments emphasized teacher training, cultivating high-quality professionals with necessary knowledge, skills, and ethics to ensure quality teaching management.

Educational policies were designed to be dynamic and context-appropriate. Coordination considered the diverse target groups and the unpredictability of the epidemic. Policy formulation aimed to balance interests among stakeholders and achieve optimal satisfaction.

2) Suggestions at the Music School Level. Teacher training was strengthened by providing free online training and regularly holding online seminars within subjects, allowing teachers to share challenges and solutions and discuss subject-specific online teaching methods. Since many teachers were unfamiliar with online platforms, schools supported training by providing software licenses and technical assistance for information-based teaching.

Universities' ensured the normal operation of technology platforms and improved digital infrastructure. Multi-school alliances were formed to explore innovative teaching programs. Art schools were encouraged to collaborate openly rather than operate in isolation, sharing intellectual resources multidimensionality.

Reasonable teaching evaluation and reward mechanisms were established, recognizing flexible and diverse teaching methods, scientifically designing mixed teaching ratios, and identifying teaching workloads. Student management was also emphasized, including timely homework completion, joint management participation with teachers, rewarding outstanding teachers and students, preventing teacher burnout, and avoiding student fatigue.

3) Micro Level: Teacher Focus. Teachers were encouraged to develop information literacy, innovate teaching models, enrich content, and habitually use online resources to think critically and solve problems. They needed to understand online teaching environments and use new cyberspaces and platforms to design suitable activities and content to achieve teaching goals effectively. Teachers' sense of responsibility and leadership were enhanced. They acknowledged that teaching environment changes affected their roles and responsibilities. They were urged to attend especially to students with difficulties or special needs to ensure educational equity.

Teacher cooperation networks were built to encourage active sharing of teaching experiences. Cooperation was divided into deep professional collaboration and daily communication and coordination. These networks provided professional, psychological, and emotional support for teachers facing pressures and anxieties during the epidemic. Harmonious teacher-student relationships were fostered. Teachers guided students to establish correct values, enhanced humanistic care, and improved students' independent learning abilities.

4) Micro Level: Student Focus. Students' information literacy, learning ability, and self-control laid a foundation for online courses. Post-epidemic blended teaching required independent learning and

communication skills. Students were expected to think critically, collaborate, analyze, speculate, and actively engage in online activities, developing scientific thinking and problem-solving skills using online resources.

This guidelines demonstrated that government, schools, teachers, and students were interconnected and mutually supportive. The government provided construction support; schools offered supervision and guidance; teachers delivered instruction; and student's maintained positive learning attitudes and mental health. The effective integration of these four components was essential to improving education management in art Universities.

According to the key-guidelines in Figure 1. The government acts as a regulator and a key pillar in enhancing educational management included teaching management quality. Educational resource provision depended heavily on government support. This research, focusing on improving education management in Liaoning Province. Focus on Art Universities, proposed strategies based on a four-helix structure involving government, schools, teachers, and student.

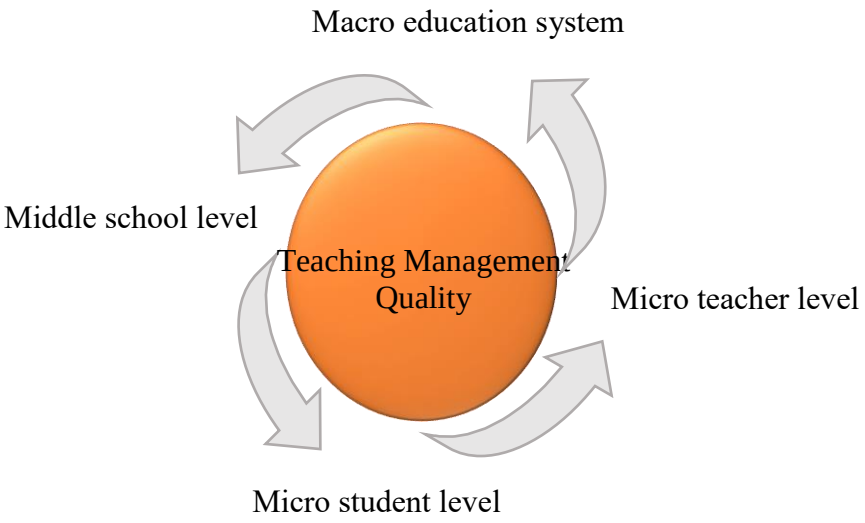

Figure 1. The government acts as a regulator and a key pillar in enhancing educational management.

Discussion

1. The current situation of art universities management in Liaoning Province

The results reveal that art universities in Liaoning Province effectively implemented strategic planning, platform collaboration, and teacher training during the post-epidemic period, highlighting the crucial role of institutional readiness. However, limitations in teachers' self-assessment and digital instructional capabilities point to a need for refined and adaptive teaching management models. This aligns with Liu (2011), who emphasized the significance of structured systems in vocational education to support teacher performance. Additionally, Min, Chen, and Zhang (2010) noted that adopting project management strategies enhances the adaptability of professional teaching, which supports findings related to tailored curricula and diverse teaching styles. The observed necessity for further technical training echoes findings by He (2020), stressing the role of applied teaching models of evolving educational demands. Furthermore, developing of multimedia-based environments, as suggested by Rao (2021), reinforces the need for continued integration of digital tools. Thus, a more systematic, technology-supported, teacher-oriented management for sustained educational quality.

2. Educational management guidelines for art universities in Liaoning Province

The findings demonstrate a comprehensive framework for improving education management in art universities, integrating government policy, institutional infrastructure, teacher professionalism, and student engagement. Promoting teacher-student collaboration and adopting innovative teaching formats aligns with Wang et al. (2020), who emphasize the benefits of mobile and collaborative learning in enhancing educational interactivity. The focus on dynamic policy formulation and quality assurance resonates with Li et al. (2014), who underscore innovation-driven educational governance. At the institutional level, strengthening teacher capacity and evaluation systems reflects the insights of Fu-Gen et al. (2010), highlighting the role of experimental teaching centers and training in improving education quality. The emphasis on digital infrastructure and resource integration supports Zhang (2019), who stresses the transformative impact of modern information technology on teaching management. Furthermore, the focus on refined management and teacher-student harmony echoes Jiang et al. (2010), advocating for multi-tiered, human-centered teaching models. Overall, these

findings underscore a holistic, stakeholder-driven strategy essential for managing post-pandemic art education effectively in Liaoning Province.

Recommendations

Recommendation for policies formulation

1. Enhance teacher-student interaction, to promote policies that support mobile and blended learning to improve communication and collaboration.
2. Strengthen online teaching capacity, to provide ongoing training and technical support for online platforms to ensure teaching quality and engagement.
3. Develop flexible management systems, to establish adaptive education management models that include mental health support and quality assurance mechanisms.
4. Invest in infrastructure and resources, to allocate funding to upgrade digital infrastructure and teaching resources, ensuring equitable access.
5. Promote inter-University collaboration, to encourage alliances among art universities to share best practices, resources, and innovative teaching strategies.

Recommendation for Practical Application

1. Implement digital teaching platforms, using reliable online systems to support curriculum delivery and student services.
2. Conduct teacher training programs, to provide regularly train educators in digital tools and innovative teaching methods.
3. Adapt curriculum for 0nline learning, developing redesign course content to suit learning outcomes.
4. Use interactive teaching techniques, to apply methods that simulate hands-on experiences and boost student engagement.
5. Establish feedback mechanisms, to create channels for ongoing feedback from students to improve teaching effectiveness.

Recommendation for Further Research

1. Explore teachers' self-assessment Skills, to study methods to enhance educators' ability to evaluate and improve their online teaching performance.
2. Examine student learning attitudes, to investigate how digital learning environments influence student motivation and engagement long-term.
3. Evaluate Curriculum Adaptability, to analyze the effectiveness of curriculum adjustments for different art disciplines in online formats.

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Educational innovation management in a Post Covid-19 Epidemic of higher education in Zhoukou under Henan Province

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ABSTRACT

The objectives were 1) to explore the components of educational innovation management in higher education and 2) to propose guidelines for educational innovation management in higher education in Zhoukou, Henan Province, in the post-COVID-19 era. employing a mixed-method approach. The population consisted of 2,408 instructors from five higher education institutions in Zhoukou, Henan Province, during the 2022 academic year. The sample was 331 instructors using Krejcie and Morgan's table, selected through stratified random sampling. Purposive sampling was used to select 17 key informants for interviews. Key informant validation was conducted using the connoisseurship approach, involving 9 experts. The guidelines were confirmed based on their input. The research instruments included a questionnaire using a five-point Likert scale and a validation checklist. Statistics for quantitative data analysis were descriptive, and content analysis for qualitative data from in-depth interviews and expert evaluations. The results revealed that 1) the components of educational innovation management in higher education in Zhoukou, Henan Province, in the post-COVID-19 era, consisted of four key elements; target innovation, curriculum innovation, organizational innovation, and scientific and technological innovation; and 2) the guidelines for educational innovation management comprised eight main strategies; optimizing educational management, enhancing administrators' learning motivation, managing and developing learning spaces, managing knowledge dimensions, improving management institutions, establishing and strengthening the management guarantee mechanisms in higher education, clarifying management objectives, and ensuring the ultimate goal of comprehensively improving the quality of educational innovation management in higher education is achieved.

Keywords: Educational Innovation Management, Post Covid-19 Epidemic, Higher Education, Zhoukou, Henan Province

Introduction

In December 2019, a viral outbreak of unexplained pneumonia occurred in Wuhan, China. On January 9, 2020, the World Health Organization (WHO) officially announced the discovery of a novel coronavirus. SARS-CoV-2 was identified as the causative agent of this infectious respiratory disease, later named COVID-19 (coronavirus disease). The success of social distancing and confinement measures in China, as well as strong recommendations from the World Health Organization, encouraged many other countries to implement similar policies. As of April 1, 2020, more than 3.4 billion people—or 43% of the world's population—had been placed under lockdown in over 80 countries and territories worldwide. These measures had an immediate and profound impact on higher education (Zhang, 2021).

The pandemic delivered unprecedented shocks to all regions of the world. Thomas Friedman compared its historical impact to all organization in time. In higher education, the COVID-19 pandemic served as a major historical turning point. The widespread adoption of online teaching completely disrupted traditional face-to-face learning in universities. In addition, the public health crisis triggered general anxiety and significantly affected students' mental health. Colleges and universities were no longer just institutions for talent development, research, and community service—they were now also key players in epidemic prevention and social stability (Sun, 2021).

In response, China's higher education system began transforming crisis into opportunity. Institutions accelerated the development of MOOCs, incorporated epidemic prevention into political education, and began documenting effective practices for improving university governance. This period also emphasized the need to guide students in developing positive societal values. According to Liu (2020), uncertainty in university governance can be categorized into three areas: uncertainty in decision-making, uncertainty in implementation, and uncertainty in the effects of implemented decisions. Therefore, this study adopts these three areas of uncertainty as a theoretical framework and uses a case study approach to explore the challenges and strategies for resilient educational innovation management during the pandemic.

This research on educational innovation management in the post-COVID-19 era in higher education institutions in Zhoukou, Henan Province, focuses on how university leaders manage through uncertainty. Effective oversight mechanisms are essential to ensure that innovation management adapts to changing circumstances. The study highlights three dimensions of uncertainty in university governance: uncertainty in decision-making, uncertainty in implementation, and uncertainty

in outcomes (Liu, 2020). Whether under ongoing pandemic conditions or in a post-epidemic recovery, educational innovation must continue to evolve in response to these uncertainties. Additionally, Sun (2021) emphasized that universities must expand their roles beyond teaching and research by actively participating in epidemic prevention and serving as essential organizations for maintaining social stability, making innovation management even more vital in the current era.

The importance of educational innovation management in Zhoukou's higher education context lies in the region's rapid growth and its need to align with national development strategies. Educational institutions in Zhoukou play a critical role in workforce development and social transformation. Without adaptive innovation management, these institutions risk falling behind in quality and relevance. Furthermore, the COVID-19 crisis exposed existing gaps in digital infrastructure, teaching models, and crisis responsiveness. Addressing these gaps through strategic innovation is not only timely but necessary for achieving long-term institutional resilience and effectiveness. This research proposes a set of actionable guidelines to help universities navigate uncertainty, reform policies, and implement flexible, future-ready management strategies in the post-COVID-19 era.

Purposes

1. To explore the components of educational innovation management in higher education in Zhoukou, Henan Province, in the post-COVID-19 era.

2. To propose guidelines for educational innovation management in higher education in Zhoukou, Henan Province, in the post-COVID-19 era.

Benefit of Research

This research on educational innovation management in the post-COVID-19 era aims to enhance cultural judgment among teachers and students, promote students' independent learning and self-management skills, and strengthen home–university co-education. It also seeks to address key educational and management challenges in Henan Province, contributing to improved leadership in higher education.

Research Process

Step 1: Conduct a comprehensive literature review and analyze related research to identify the components of educational innovation management in higher education institutions in Zhoukou, Henan Province, in the post-COVID-19 era.

Step 2: Develop semi-structured interview questions based on the literature review from Step 1. Use the interview findings to design a questionnaire for data collection and analyze.

Step 3: Apply the connoisseurship approach by engaging nine experts to propose and verify the guidelines. The guidelines were finalized based on expert input and obtained through purposive sampling.

Population, Sample, and key informants

The population consisted of 2,408 instructors from five higher education institution Using Krejcie and Morgan (1970) and stratefied random sampling, a sample of 331 instructors. Purposive sampling was used to select 17 key informants for interviews, comprising 11 administrators and instructors, and six students. Key informant validation was conducted using the connoisseurship approach, involving nine experts to verified guidelines and confirmed.

Instruments and data analysis

Instruments

1. Semi-structured Interview Guide: A semi-structured interview form was developed based on the literature review to explore components and practices of educational innovation management in higher education during the post-COVID-19 era in Zhoukou, Henan Province, China. This tool was used to gather qualitative data from 17 key informants, including administrators and instructors.

2. Questionnaire: questionnaire was constructed from the findings of the literature review and interview analysis. It was used to collect quantitative data from a stratified random sample of 331 instructors. The instrument was questionnaire to measure the level of educational innovation management and was analyzed using descriptive statistic.

3. The connoisseurship approach was employed with nine experts to verify and propose guidelines for educational innovation management in higher education in Zhoukou, Henan Province, in the post-COVID-19 era.

Data analysis

1. Qualitative Analysis. Content analysis was conducted on the data collected from in-depth interviews. The responses were coded and categorized based on recurring themes and frequencies to identify key components and challenges of educational innovation management.

2. Quantitative Analysis: Data from the questionnaire survey were analyzed using descriptive statistics (frequency, mean, percentage, and standard deviation) and Exploratory Factor Analysis (EFA) to identify the underlying dimensions of educational innovation management.

3. Connoisseurship. A moderated focus group discussion was conducted to validate and refine the proposed guidelines. Nine experts participated voluntarily and provided feedback based on their expertise. This step helped ensure the practical relevance and clarity of the final guidelines.

Conclusion and discussion

Conclusion

1. Research results section 1

A content analysis of the literature review and related studies, along with an analysis of data collected from the sample questionnaire, was conducted to examine the influence of educational innovation management in higher education after the COVID-19 pandemic. Based on the review of literature and prior research, eight main variables and 39 sub-variables were identified. Using these variables as a foundation, the researcher developed a semi-structured interview guide and conducted interviews with 17 key informants, all of whom were instructors involved in educational innovation management in higher education.

The demographic analysis of the 331 respondents (n = 331) offers a clear overview of the participant profile in this study on educational innovation management. A total of 203 respondents were male (61.3%) and 128 were female (38.7%). In terms of age, 226 participants (68.3%) were between 20 and 44 years old, while 105 participants (31.7%) were aged 45 and above. Regarding educational background, 90 respondents (27.2%) held a bachelor's degree, whereas 241 (72.8%) held qualifications higher than a bachelor's. As for professional experience, 232 individuals (70.1%) had less than 15 years of work experience, while 99 individuals (29.9%) had 15 years or more. This distribution reflects a predominantly young, well-educated, and early- to mid-career group, offering valuable insights into perspectives on educational innovation in higher education. Questionnaires result 1-5, as below.

1. The results from indicate that the current situation in educational innovation management at the university, in the post-COVID-19 era, is at the highest level overall ($\bar{x}$ = 4.74, S.D. = 0.88), reflecting a strong institutional commitment to innovation. The three highest-ranking items demonstrate key strengths: first, the degree of support for the key success factors prioritized by university administrators (Q5) had the highest mean ($\bar{x}$ = 4.90, S.D. = 0.91), showing that leadership is highly supportive and strategic in fostering innovation. Second, brainstorming opinions on current management measures of educational innovation (Q3) scored a high mean of mean ($\bar{x}$ 4.80, S.D. = 0.86), indicating active participation and collaborative input in shaping innovation practices. Third, the implementation of educational innovation and resource organization (Q4) received a mean of ($\bar{x}$ =4.70, S.D. = 0.90), highlighting the university's effectiveness in mobilizing and managing key resources—human, financial, material, and managerial—to support innovation. These results reflect a strong post-pandemic response through strategic leadership, collaborative input, and resource integration to enhance educational innovation.

2. The results from Table 4.4 demonstrate that the components of Educational Innovation Management in Zhoukou higher vocational higher education institutions are perceived at a highest level overall ($\bar{x}$ = 4.76, S.D. = 0.89), indicating a strong and systematic approach to innovation in the post-COVID-19 context. Focusing on the three highest-ranking components, the first is Q (10) – "the degree of support for the key success factors to which the administrators of the university attach importance to educational innovation management" – which received a mean score of ($\bar{x}$ = 4.90, S.D. = 0.89). This reflects a strong commitment from university leadership, underscoring that strategic direction and administrative prioritization are central to innovation success. The second highest component is Q (12) – "the degree of support for the establishment of research topic courses for educational innovation management" – with a mean of ($\bar{x}$ = 4.85, S.D. = 0.91). This result emphasizes the university's emphasis on embedding innovation into research and academic development, which enhances both knowledge creation and instructional quality. The third is Q(7) – "understanding the extra points of the educational innovation management system of your university" – scoring ($\bar{x}$ = 4.82, S.D. = 0.85), suggesting that faculty and stakeholders possess a clear awareness of the system's distinctive strengths and added value, which is vital for effective and consistent implementation.

These high scores collectively illustrate that the university not only emphasizes leadership and research in innovation but also cultivates deep understanding among its personnel, creating a strong foundation for sustained educational transformation.

3. The results the Functional and Structural Educational Innovation Management at Zhoukou higher vocational higher education institutions is perceived at the highest level overall ($\bar{x}$ = 4.77, S.D. = 0.89), indicating a strong institutional response to the demands of post-COVID-19 educational transformation. The three highest-ranking components provide key insights into this strength. The highest-rated item is Q (22) – "the degree of support for the structural adjustment of university education innovation management" – with a mean score of ($\bar{x}$ = 4.95, S.D. = 0.91), reflecting the institution's robust commitment to reforming and adapting its structure to better support innovation in the new educational landscape. The second is Q (21) – "your understanding of the function of the innovation management of university education in the epidemic situation" – which scored ($\bar{x}$ = 4.80, S.D. = 0.88), showing that stakeholders clearly understand the functional role of innovation management during crises, an essential factor for effective adaptation and resilience. The third is Q (19) – "your recognition of the current capabilities of innovation management in university education that has played a role in the

pandemic" – with ($\bar{x}$ = 4.75, S.D. = 0.90), indicating a high level of appreciation for the system's effectiveness and contribution during the COVID-19 crisis.

These findings together suggest that the university has successfully aligned both its organizational structure and functional understanding of innovation management to address the evolving challenges of higher education, making it well-positioned for sustainable innovation moving forward.

4. The results from the Best Practice of Educational Innovation Management in Zhoukou higher vocational higher education institutions is rated at the highest level overall ($\bar{x}$ = 4.78, S.D. = 0.90), reflecting strong implementation and perception of best practices in the post-COVID-19 era. The highest-ranked item is Q (27) – "recognition of student-centered education innovation management as a best practice" – with a mean of ($\bar{x}$ = 4.90, S.D. = 0.89), indicating a strong emphasis on learner-focused approaches, which align with modern educational paradigms that prioritize engagement, autonomy, and adaptability. The second is Q (26) – "the importance of managers in the practice of educational innovation management" – scoring ($\bar{x}$ = 4.85, S.D. = 0.85), highlighting the vital role of educational leadership in driving and sustaining innovative practices within institutions. The third is Q (24) – "the importance of university teaching methods in the practice of educational innovation management" – with a mean of ($\bar{x}$ = 4.73, S.D. = 0.93), which shows a strong awareness of the need to innovate pedagogical approaches as part of overall educational reform.

Together, these results underscore that student-centered learning, managerial leadership, and innovative teaching methods are key pillars of best practice in educational innovation management, ensuring responsiveness to both learner needs and institutional development goals.

5. The findings from the key success factors of Educational Innovation Management in Zhoukou higher vocational higher education institutions are rated at the highest overall level ($\bar{x}$ = 4.88, S.D. = 0.90), indicating a strong institutional focus on the foundational drivers that contribute to successful innovation. The highest-ranked factor is Q (29) – "the importance of management awareness in the management of educational innovation" – with a mean of ($\bar{x}$ = 4.95, S.D. = 0.89). This reflects the crucial role of informed, proactive, and innovation-oriented leadership in shaping and guiding educational transformation. When management understands the importance of innovation, they are better positioned to allocate resources, design strategies, and foster a culture that supports sustainable change. The second-ranked item is Q (28) – "degree of recognition of

university administrators as key success factors" – scoring $\bar{x}$ = 4.90, S.D. = 0.91, which emphasizes the importance of administrators' leadership roles. Their decisions, vision, and support directly influence the success of innovation policies and practices across the institution. The third-ranked factor is Q (30) – "the importance of doing a good job of student work in the management of educational innovation" – with $\bar{x}$ = 4.80, S.D. = 0.90, showing that student services and support mechanisms are also vital. Effective student engagement ensures that innovation meets learners' needs and contributes to improved outcomes and satisfaction.

In summary, the most critical success factors lie in the awareness, leadership, and active involvement of management, along with a strong student-centered focus, all of which form a solid foundation for advancing educational innovation.

6. The results in the institutional assessment of educational innovation management is perceived at a highest level overall, with a mean score of ($\bar{x}$ = 4.66, S.D.=0.89). The highest-ranked item is the uniqueness of the overall educational innovation management assessment system (Q39), with a mean of ($\bar{x}$ = 4.70, S.D. = 0.91), indicating a strong consensus on the importance of having a distinct evaluation framework. The second-ranked item is the use of managers' salaries as a criterion for assessment (Q37), with a mean of ($\bar{x}$ = 4.65, S.D. = 0.89), reflecting agreement on the value of performance-based incentives in innovation management. The third-ranked item is the recognition of teacher attendance awareness as an assessment standard (Q38), with a mean of ($\bar{x}$ = 4.65, SD. = 0.88), showing that consistent teacher presence is also a significant factor in evaluating innovation. These results underline that effective institutional assessments after the COVID-19 pandemic should balance structural uniqueness, managerial accountability, and faculty involvement.

According to the first research objective, in-depth interviews were conducted with 17 key informants to explore the challenges faced in the post-epidemic period and to develop the components of educational innovation management in higher education institutions in Zhoukou, Henan Province. The research process and findings are summarized as follows: Step 1: The researcher conducted in-depth interviews with 17 key informants, including university administrators and instructors, to gather qualitative data on the problems and needs related to educational innovation management after the COVID-19 epidemic. Step 2: The interview data were carefully transcribed, coded, and analyzed using content analysis to identify recurring themes and categories relevant to innovation management in the higher

education context. Step 3: Based on the frequency from interview of 17 key informants, the researcher summarized and prioritized the components as table 1 follow.

Table 1 Educational innovation management in higher education institution in Zhoukou

Interview summarized	n=17
1. The current management content	
1.1 The complexity of the management environment is highlighted	16
1.2 Ineffective management	16
1.3 Unclear management objectives	16
1.4 Management learning space is narrow	15
1.5 Manage one-dimensional knowledge transfer	15
1.6 Teaching management content is indoctrinated	14
1.7 Managers have varying levels of competence	14
1.8 Lack of motivation for managers to learn	13
2. Improving the management ways	
2.1 Innovation management methods	16
2.2 Characteristic management	15
2.3 Development management	14
2.4 The combination of online and offline	14
2.5 Innovate the education management model	13
3. Actively implement the current policy measures	
3.1 Renewal of teaching concepts	13
3.2 Strengthen the management ability	13
3.3 The school restructured the curriculum	12
3.4 Implement the management effectiveness and evaluation of course content	12
3.5 Refine the understanding and service of students under management	11
3.6 Strengthen the formulation of educational management plans and policies	11
4. Awareness of education innovation management	
4.1 Management innovations awareness	15
4.2 Characteristic management concepts awareness	14
4.3 Innovative quality of cultivate management awareness	13
4.4 Educate the mind and lead the awareness	13
4.5 Moral personality management awareness	12
5. the other management guidance	

5.1 Perfect principles of management	16
5.2 Method of management reformation	16
5.3 Draw up personnel manager training	15
5.4 Perfect management standard	13

Table 1. Based on the in-depth interviews with 17 key informants, the findings reveal several critical aspects of educational innovation management in higher education in Zhoukou, Henan Province, during the post-COVID-19 era. The current management content was reported to be problematic, with 16 participants highlighting the complexity of the management environment, ineffective practices, and unclear objectives. Many also noted limitations in learning spaces (15 responses) and the one-dimensional nature of knowledge transfer. Teaching management was often described as overly indoctrinated (14), with inconsistent competency among managers and a lack of motivation to pursue further development. To improve management approaches, the interviewees recommended adopting innovative and characteristic methods (16 and 15, respectively), focusing on development-oriented strategies (14), and integrating online and offline management models. Policy implementation was seen as essential, with emphasis on renewing teaching concepts, strengthening capabilities (13 responses), restructuring curricula (12), and refining both course evaluation and student services. Additionally, participants emphasized the importance of fostering awareness around innovation in management, including moral and characteristic aspects (13–15 responses). Lastly, the need for clearer management principles and reformative methods was strongly expressed (16 responses), alongside the development of structured training and standards for educational managers. These insights collectively form the basis for proposing comprehensive and context-specific management guidelines.

2. Research results section 2

The connoisseurship approach by engaging nine experts to propose and verify the guidelines. Nine expert verified and guidelines as Table 2.

Table 2. Connoisseurship result

Connoisseurship to propose and verify the guidelines (9 experts)											
	Item	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Expert8	Expert9	n=9
1	Improve the university innovation management platform	✔	✔		✔	✔	✔		✔		6
2	Promote the practice of innovation management in higher education.	✔		✔	✔	✔	✔	✔			6
3	Improve the innovation management mechanism of universities.	✔	✔	✔	✔	✔					5
4	Improving the concept of innovation management in Higher Education	✔		✔	✔	✔		✔			5
5	Understanding the current situation of innovation management in Higher education	✔		✔	✔		✔				4
6	Understand the factors of innovation management in Higher education	✔			✔	✔		✔			4
7	Understanding the current situation of innovation management in Higher education	✔		✔					✔	✔	4

Based on Table 2, which presents the connoisseurship evaluation by nine experts, the researcher identified key priorities to enhance innovation management in higher education. The findings show that the most frequently agreed-upon strategies include improving the university innovation management platform (6 out of 9 experts),

promoting the practice of innovation management in higher education (6), and enhancing the innovation management mechanisms in universities (5). Additionally, improving the conceptual understanding of innovation management (5), and gaining insights into the current situation and influencing factors (each with 4 expert endorsements) were also considered essential.

These findings support a multi-faceted approach to strengthening innovation management, as further elaborated by the experts. First, there is a need to cultivate awareness of educational innovation management among higher education administrators. This can be achieved through increased government support and collaboration among stakeholders—including schools, families, and government agencies—to establish joint training mechanisms and long-term development plans. Reforming college-level innovation management structures and improving policy guidance were also emphasized.

Second, innovation management must balance theoretical instruction with practical application. Experts suggest developing structured curricula focused on competency-based training, improving the innovation capabilities of administrators through formal coursework, and enhancing institutional systems that support such innovations.

Third, strategic guidance is critical. The government should align educational innovation efforts with local socio-economic characteristics by appointing qualified experts, forming local education management committees, and tailoring training goals to regional needs. Establishing a robust assessment and monitoring system is also necessary. This includes clarifying roles and responsibilities of administrators, setting operational standards, and ensuring transparent oversight and evaluation by designated innovation management bodies.

Overall, the convergence of expert opinions underscores the importance of systemic reform, capacity building, and policy-driven innovation to advance higher education management in the post-pandemic context.

The component of educational innovation management mainly uses quantitative analysis methods, and after descriptive statistical analysis such as average and variance, the target innovation, curriculum innovation, organizational innovation, and technological innovation are studied, and their effective components for educational innovation management are determined. Finally, the qualitative analysis method discussed by the expert group was adopted to analyze the educational management innovation, and a guideline for educational innovation management was

developed. Data analysis framework diagram for Educational Innovation Management in a Covid-19 epidemic of Higher Education in in Zhoukou under Henan Province.

The figure1. Show the framework of Educational Innovation Management in Universities in the post-COVID-19 epidemic, highlighting the interconnected components and driving factors. Here's a concise summary;

1) Current situation. The foundation of the model starts with an assessment of the current state of Educational Innovation Management in universities after COVID-19, which influences and is influenced by other components.

2) Core components of Innovation Management, categorized into four main components: (1) Goal innovation, (2) Curriculum innovation, (3) Organizational innovation, and (4) Technological innovation. These form the structural basis for managing change and development in higher education.

3) Role of leadership and faculty. Innovative management from leaders and teachers is crucial. It supports: (1) Functional and structural adjustments in innovation management, (2) Identification of best practices, (3) Understanding of key success factors, (4) Development of countermeasures for post-epidemic challenges, and (5) Promotion of awareness regarding educational innovation

4) Institutional assessment, all innovations and strategies are subjected to institutional assessment, which helps close the feedback loop and ensures accountability and continuous improvement.

5) Final integration, all elements contribute to an overarching of innovative management, ensuring a systematic, multi-level approach that aligns with institutional goals, practices, and post-pandemic recovery.

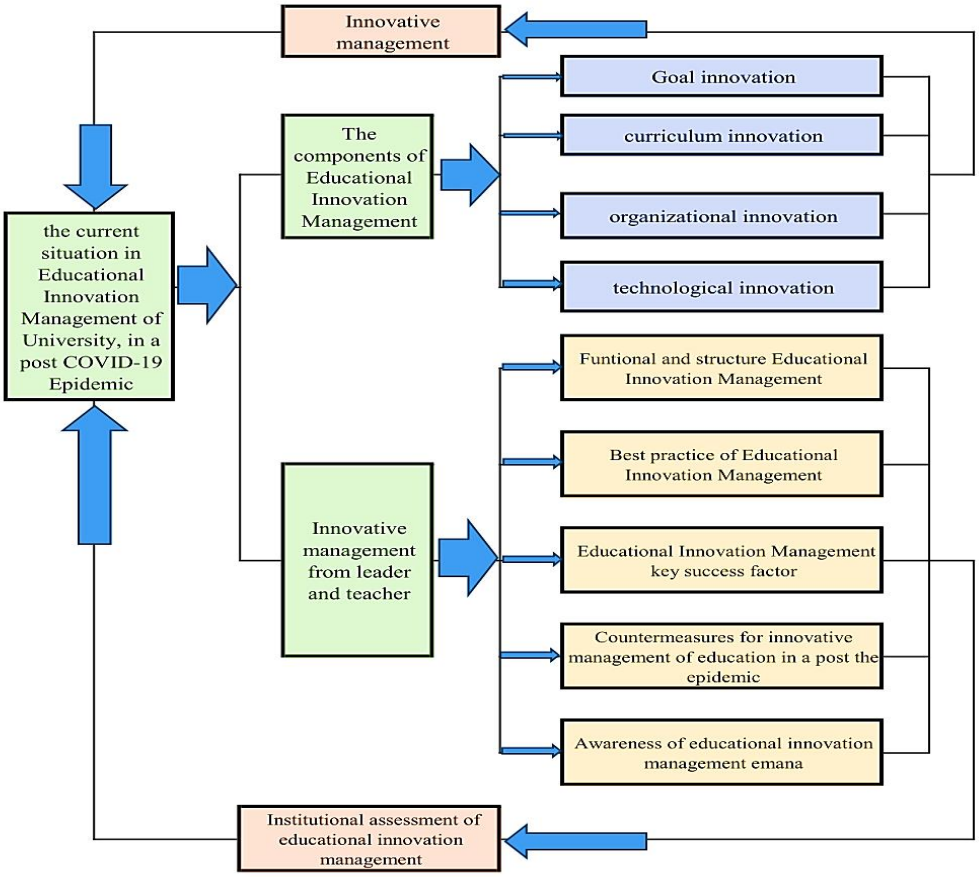

Figure 1. Framework of Educational Innovation Management in Universities in the post-COVID-19 epidemic, highlighting the interconnected components and driving factors

Discussion

Based on the research findings from objectives 1 and 2, the framework for Educational Innovation Management in universities during the post-COVID-19 period can be comprehensively discussed through four core components: goal innovation, curriculum innovation, organizational innovation, and technological innovation.

First, goal innovation emphasizes aligning institutional goals with post-pandemic recovery and community needs. Andreas Schleicher (2020) points out the urgency for education systems to redefine their missions and embrace adaptability in times of crisis. Similarly, David Maurrasse (2020) highlights how universities must support local development goals, requiring a clearer innovation direction that includes stakeholder collaboration.

Second, curriculum innovation is critical for integrating theory and practice in educational design. Chen Wei (2019) and Hua Qiang (2020) suggest restructuring teaching strategies through competency-

based and blended learning, supported by digital systems. These innovations ensure that academic programs are responsive to student needs and societal shifts.

Third, organizational innovation involves reforming structures and administrative processes to better facilitate innovation. As Ase Gornitzka (2019) explains, organizational agility is essential during crises. Leadership commitment, faculty involvement, and policy realignment must be coordinated. Chen Yue (2020) and Li Xu (2015) further advocate for web-based academic management systems to streamline innovation practices within institutions.

Fourth, technological innovation remains indispensable. Digital tools and platforms must be integrated into every facet of university management. Zhou Yue (2020) and Silvia Gomez Recio (2020) emphasize how robust digital ecosystems support learning continuity and administrative efficiency, while Hu Shanshan (2020) demonstrates the role of online quality assurance systems in maintaining academic standards.

The integration of these four components—supported by expert insights and empirical findings—forms a dynamic system that drives educational innovation. Institutional assessment mechanisms ensure feedback loops that refine practices continuously. This multi-level approach, grounded in both qualitative and quantitative findings, addresses post-pandemic challenges and reflects a forward-looking educational management paradigm (Li Hailong, 2020; Song Lei, 2020; Zhang Zhong, 2021; Fuan, 2020).

Recommendations

Recommendation for policies formulation

1. Strengthen leadership capacity. Enhance the strategic role and innovation management skills of university administrators.
2. Build an innovation ecosystem. Establish an integrated system that promotes sustainable and collaborative educational innovation.
3. Promote student-centered practices. Implement innovative, practice-based, and student-focused teaching methods.
4. Improve assessment systems. Develop robust evaluation mechanisms to ensure quality and effectiveness in innovation management.

Recommendation for practical application

1. Conduct training programs for University Leaders. Organize workshops and continuous professional development to build competencies in innovation leadership and strategic planning.
2. Develop collaborative innovation projects. Encourage partnerships among faculty, students, and external stakeholders to

co-create and test innovative teaching models and educational technologies.

3. Implement innovation performance dashboards. Create digital tools to monitor, assess, and report progress in educational innovation, ensuring alignment with institutional goals and quality standards.

Recommendation for Further Research

1. Explore long-term impact of post-COVID educational innovation future studies should investigate how educational innovation management practices adopted during the COVID-19 pandemic have sustained or evolved in the long term across different types of universities.

2. Examine student and faculty perspectives. Research should focus on perceptions and experiences of students and faculty regarding the effectiveness and challenges of innovation management, which were not deeply addressed in the current study.

3. Compare innovation management across institutions. Comparative studies between public and private universities or across regions would help identify contextual factors that influence successful innovation management.

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Integration of Capsule Network with CNN for Plant Leaf Disease Classification

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ABSTRACT

Plant leaf disease classification is challenging due to the wide variation in disease symptoms and the diverse morphological characteristics of plant leaves. These variations complicate model training and hinder classification accuracy. This study proposed a hybrid deep learning (DL) model for leaf disease training and classification. The proposed model integrates Capsule Networks (CN) for spatial relationship retention, SE-Residual blocks improve feature extraction while minimizing information loss, and CN capture spatial relationships with reduced dependency on large datasets, and Long Short-Term Memory (LSTM) to enhance training efficiency. The proposed model was trained and evaluated using the Rice Leaf Disease Dataset (RLDD). Its performance was compared with existing state-of-the-art models. The experimental results showed that the proposed model achieved the highest training accuracy of 96.01%, classification results 75.67% for bacterial leaf blight, 80.43% for brown spot, 86.67% for healthy, 76.52% for leaf blight, 98.96% for leaf scald, and 93.18% for narrow brown spot. These results highlight the effectiveness of the proposed model in achieving high accuracy for plant leaf disease classification.

KEYWORDS: Plant leaf disease classification, Integration networks, Convolutional neural network, Deep learning.

Introduction

Plant diseases reduce the quality and quantity of crops in agriculture worldwide (Ristaino et al., 2021; Karthickmanoj et al., 2024; Gai et al., 2024). These diseases not only cause economic losses but also threaten global food security, making their identification and management essential to minimize their impact. Traditional methods for plant disease identification rely on visual inspection or diagnosis by experienced personnel, which is both time-consuming and dependent on specialized expertise. These methods often fail to provide the speed and accuracy required in modern agriculture. In resource-limited settings, the reliance on manual monitoring further complicates disease management, resulting in delays in diagnosis and preventive actions. These challenges highlight the need for new technologies and methods to identify plant diseases more quickly, accurately, and efficiently. DL has gained significant attention for its potential to address these limitations by reducing reliance on manual inspection and improving the accuracy of plant disease diagnosis (Heng et al., 2024; Sarkar et al., 2023).

In recent years, DL, especially CNN, has gained much attention for its ability to learn and extract spatial features, making it suitable for analyzing plant leaf diseases. (Singh et al., 2017) (Mahadevan et al., 2024). This has led to significant progress in developing techniques for leaf disease detection and classification, such as (Thaseentaj et al., 2023) proposed a customized deep CNN with a deeper structure and the ability to learn complex features from data to address issues affecting yield and quality in mango leaf disease detection and classification. (Paul et al., 2023) proposed a web and android application has been designed to assist farmers with real-time classification of tomato leaf diseases. The system integrates state-of-the-art VGG16 and VGG19 networks, trained using transfer learning, and emphasizes data augmentation to improve model accuracy. (Hessane et al., 2023) proposed image analysis combined with machine learning, focusing on feature extraction based on 80 gray level co-occurrence matrix and HSV features. It is tested with support vector machine, k-nearest neighbors, random forest, and light gradient boosting machine to detect and classify disease outbreak levels. (Ta ji et al., 2024) ensemble DL by combining CNN and Local Binary Pattern with binary dragonfly, ant colony, and moth flame optimization for plant leaf disease classification. (Muthusamy et al, 2024) ensemble learning with CNN by tuning parameters in dense layers and combining multiple networks using an averaging strategy. This approach aims to enhance classification efficiency through experimentation with three types of networks. These studies highlight the potential of CNN

in plant disease analysis and classification. However, refining and optimizing their structure remains crucial for addressing challenges in agricultural applications.

Despite the advancements in CNN-based models, existing methods struggle with image variations, leading to misclassification. This study aims to address these challenges by integrating advanced DL components, including CN, SE-residual networks, and LSTM to improve the model's accuracy and learning capability. SE-residual address the efficiency degradation in deep networks by preserving critical information during learning, while CN capture complex structures and spatial relationships in data, reducing the dependency on large datasets and artificial data augmentation. By combining these techniques, the model can be adapted to more complex data, making it particularly effective for agricultural applications.

Objectives

1. To study DL networks, specifically CNN and Capsule Networks, for plant disease classification.

2. To integrate Capsule Network with CNN to improve the accuracy of plant leaf disease classification.

Hypothesis

1. Noisy leaf characteristics interfere with the network's ability to effectively learn and classify leaf disease characteristics.

2. The integration of Capsule Networks with CNN improves training efficiency and increases the accuracy of leaf disease classification compared to individual networks like CNN or other common models.

Expected Benefits

1. Enhance the efficiency of DL models for accurate plant disease classification.

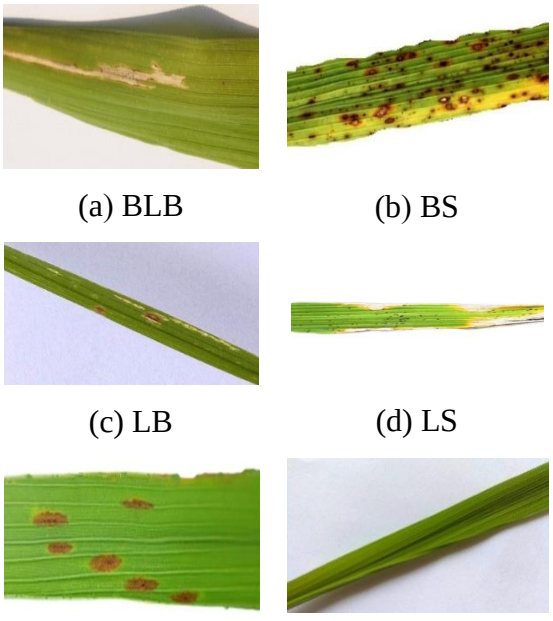
2. Provide guidance for developing mobile applications for plant leaf disease classification systems.

Experimental Method

Dataset

This study utilized a disease dataset, with the rice leaf diseases dataset (RLDD) (Singh et al., 2020) was used for experimentation. It contains 2,628 rice leaf images categorized into six types of diseases: bacterial leaf blight (BLB), brown Spot (BS), leaf blast (LB), leaf scald (LS), narrow brown spot (NBS), and healthy (HE), with each category consisting of 428 images, are shown in figure 2. The images were organized and categorized for training and testing the DL. The dataset was divided into a training set comprising 80% of the data (60% for training

and 20% for validation) and 20% for testing set.



(a) BLB (b) BS

(c) LB (d) LS

(e) NBS (f) HE

Figure 1: RLDD dataset.

Deep Learning Network Design

The experimental VGG19 model is modified and enhanced to improve its processing and learning efficiency, (referred to as Modified VGG19), in combination with the design approach presented (Zhang et al., 2024). SE-SK-CapResNet is proposed as an artificial neural network (ANN) that integrates residual blocks and CN to enhance data collection and processing capabilities. This architecture is designed to improve model performance across all dimensions.

Figure 2 illustrates the Modified VGG19 model implemented this approach by defining convolutional layers, as described in Equation 1, with filter sizes of 64, 128, and 256, increasing progressively in each block to capture data features, using 3×3 filters with SAME padding to preserve image dimensions during computation. For spatial dimensionality reduction, a 2×2 MaxPooling2D layer with a stride of 2 is used to highlight significant features.

The output is then passed through the SE-Residual block, which applies filters of sizes 64, 128, and 256 with a stride of 2 to enhance the efficiency of feature aggregation across multiple channels. The results from the SE-Residual block are forwarded to a CN layer, configured with 32 capsules and a capsule dimension of 8, utilizing 3×3 filters with a stride of 2 to capture detailed spatial relationships.

Subsequently, the data is passed into an LSTM layer with 128 units, incorporating a dropout rate of 0.2 to prevent overfitting and optimize the learning potential of the data sequence. Finally, the output is processed by a SoftMax layer to convert the results into probabilities for classifying the data into corresponding categories.

$$y_{i,j} = \sum_{m} \sum_{n} x_{(i+m),(j+n)} \cdot k_{m,n} + b \quad (1)$$

When $x_{(i+m),(j+n)}$ input at position *(i+m, j+n)*, $y_{i,j}$ is the output at pixel *(i, j)*, $k_{m,n}$ denotes the filter at position *(m, n)*, and *b* is the bias term.

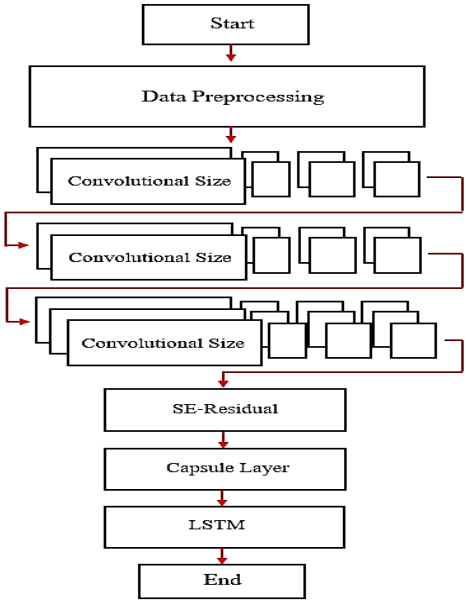


Figure 2: Proposed method.

In this experiment, the researchers performed data cleaning (DC) to change the characteristics of the experimental images by creating a function to detect excessive background color levels and calculating the ratio of pixels with intensity values lower than 30 to pixels in the image and comparing it to a threshold value set at 0.8 of the images, which sets the ratio exceeding the threshold value to zero. The image after DC shown in figure 3.

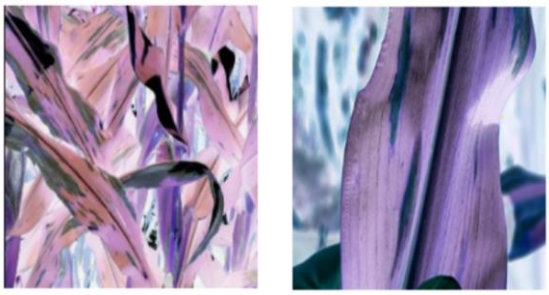


Figure 3: Image transformed using thresholding.

The proposed network was trained using the parameters summarized in Table 1.

Table 1: Parameter for training model.

Parameter	Value
Image size	224x224x3
Learning rate	10^{-3}
Epoch	50
Batch size	64
Loss function	Categorical crossentropy
Optimization	Adam

Evaluation

Accuracy is used to evaluate training efficiency by calculating the ratio of correctly predicted samples to the total number of samples as:

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN} \quad (2)$$

Where true positive (TP) refers to the number of correct samples accurately predicted by the model, true negative (TN) represents the number of incorrect samples correctly identified as negative, false positive (FP) indicates the number of

incorrect samples mistakenly predicted as positive, and false negative (FN) denotes the number of correct samples that the model incorrectly predicts as negative.

The confusion matrix was utilized to analyze and present the classification results of the model, with the outcomes displayed in a tabular format for better interpretation (Krstinić et al., 2024).

Result

Training Performance

Figure 4 illustrates the comparative performance of models trained on the RLDD dataset. The Modified VGG19 model achieves the highest performance with an accuracy of 89.93%. In contrast, VGG19 achieves the next highest accuracy at 88.12%.

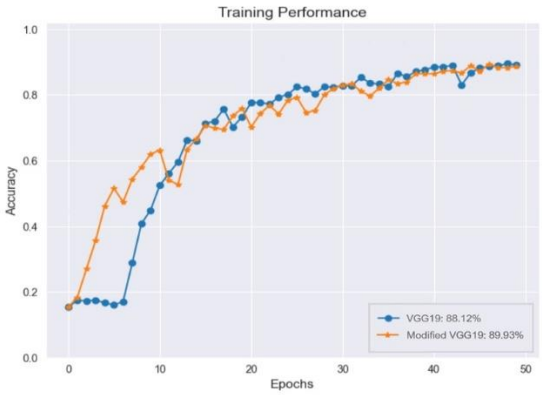


Figure 4: Training performance of RLDD.

Figure 5 illustrates the comparative performance of models trained with DC on the RLDD dataset. The Modified VGG19 model achieves the highest performance with an accuracy of 96.01%, demonstrating consistent training progress from the initial epochs (0–10) and maintaining stability throughout the training process. In contrast, VGG19 achieves the next highest accuracy at 93.98%.

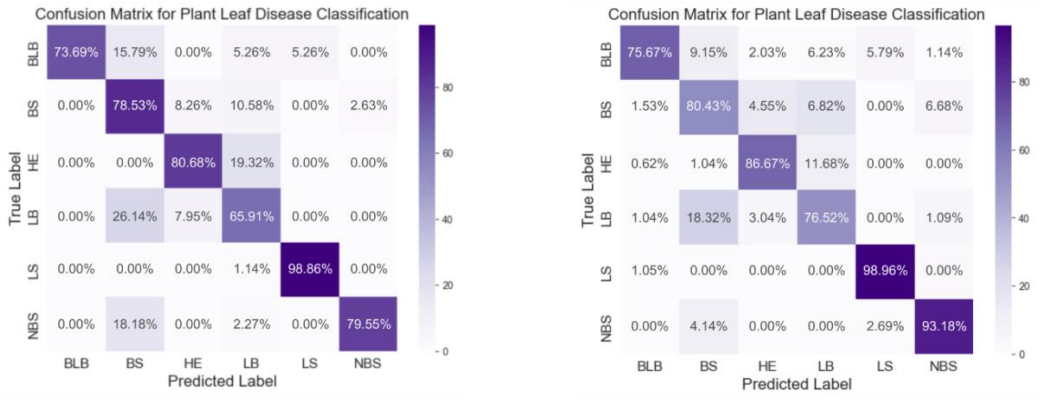
Figure 5: Training performance with DC of RLDD.

Classification Performance

After training, the network was tested for its ability to classify plant leaf diseases, and the results are presented in the confusion matrices shown in figure 4.

Figure 6 compares the performance of VGG19, and Modified VGG19 models in classifying leaf diseases using the RLDD dataset, as represented by their respective confusion matrices. The Modified VGG19, while reducing some errors, still exhibited significant challenges in classification. It performed relatively well in certain groups, such as LS at 98.96%, and BLB at 93.18%, but showed considerable confusion in the HE, BS, LB, and BLB groups, limiting its overall effectiveness. VGG19 achieved the second-highest accuracy, performing well in the LS groups with a TP rate of 98.86%.

However, it struggled in classifying similar data, as reflected by lower TP rates in the HE at 80.68%, NBS at 79.55%, BS at 78.53, and BLB at 73.69% groups, but showed considerable confusion in the HE, NBS, BS, and BLB groups, limiting its overall effectiveness highlighting its limitations in distinguishing overlapping features. These results demonstrate the outstanding performance of the Modified VGG19 model in handling complex data within high-performance training sets; however, improvements are still needed in the classification component of the dataset to achieve even higher accuracy.



(a) CNN (VGG19)

(b) Modified VGG19

Figure 6: Classification results for the RLDD.

Comparison Performance

In this experiment, state-of-the-art techniques were evaluated for comparison with the proposed method. These included ResNet50 (Adnan et al., 2023), ResNet101 (Sethy et al., 2024), DenseNet121 (Huang et al., 2017), and InceptionV3 (Szegedy et al., 2016), all trained using standardized parameters outlined in table 1. The training performance is illustrated in figure 5.

Figure 7 shows the training results on the RLDD dataset. InceptionV3 achieved the highest efficiency at 80.87%, with rapid initial learning and stable performance. DenseNet121 followed at 73.76%, showing steady improvement. In contrast, ResNet101 and ResNet50 had the lowest efficiencies, at 25.08% and 24.05%.

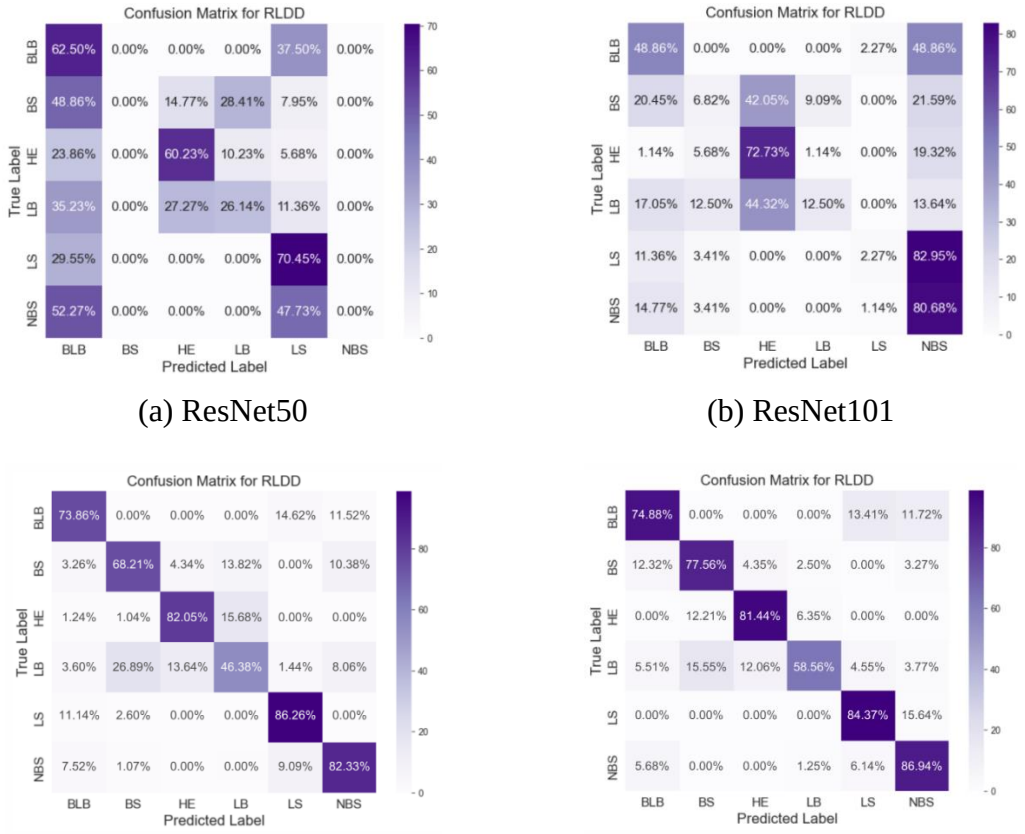
Figure 7: Training performance of DL with the RLDD.

The comparison performance training results shown in table 2.

Table 2: Comparison performance.

Model	RLDD
VGG19	93.98%
Modified VGG19	96.01%
Resnet50	24.05%
Resnet101	25.08%
DenseNet121	73.76%
InceptionV3	80.87%

When the training model were tested for classification performance, shown in figure 8.



(a) ResNet50

(b) ResNet101

(c) DenseNet121

(d) InceptionV3

Figure 8: Classification results of DL with the RLDD.

Figure 8, the confusion matrix for the RLDD, showing that DenseNet121 and InceptionV3 outperform ResNet50 and ResNet101. DenseNet121 achieves the highest TP rates across groups, including LS at 86.26%, NBS at 82.33%, and HE at

82.05%, while InceptionV3 performs well in NBS at 86.94%, LS at 84.37% and HE at 81.44%. In contrast, ResNet50 and ResNet101 perform poorly, with ResNet50 achieving low TP rates in LS at 70.45% and BLB at 62.50%, and ResNet101 struggling in LS at 2.27%, BS at 6.82% and LB at 12.50%.

Discussion

Plant leaf diseases classification is challenging due to the variations in disease symptoms, which often lead to misclassification. This study presents a hybrid DL model for leaf disease training and classification. The proposed model integrates CN, SE-Residual Blocks, and LSTM to enhance training efficiency. The design employs an improved convolutional operator to efficiently extract features, followed by SE-Residual blocks to emphasize critical features and address the issue of information loss. CN are utilized to capture complex structures and spatial relationships. The researchers performed DC to change the characteristics of the experimental images by creating a function to detect excessive background color levels and calculating the ratio of pixels with intensity values lower than 30 to pixels in the image and comparing it to a threshold value set at 0.8 of the images, which sets the ratio exceeding the threshold value to zero. The experimental results show that this approach outperforms existing models, improving classification accuracy and overall efficiency. This design expands upon the study in (Zhang et al., 2024) to further enhance its capabilities.

Conclusion

This experiment focuses on advancing hybrid DL model for leaf disease training and classification. The proposed model integrates CN, SE-Residual Blocks, and LSTM to enhance training efficiency. The design employs an improved convolutional operator to efficiently extract features, followed by SE-Residual blocks to emphasize critical features and address the issue of information loss.

The proposed model was trained on the RLDD datasets, achieving maximum training accuracy of 96.01%. During testing, the model demonstrated outstanding classification accuracies of 75.67%, 80.43%, 86.67%, 76.52%, 98.96%, and 93.18% for BLB, BS, HE, LB, LS, and NBS. These results highlight the proposed method's superior accuracy and efficiency compared to previous studies, establishing it as a reliable solution for plant leaf disease classification across diverse environmental conditions.

In the future, research aim to development networks capable of classification datasets with higher

accuracy, ultimately providing an efficient and accessible tool for plant leaf disease classification in agriculture.

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Guidelines for developing Kasem Bundit University, Thailand into a Green University according to UI Green Metric Standards and sustainable development goals (SDGs)

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ABSTRACT

This study aimed to develop a comprehensive framework and practical strategies for transforming Kasem Bundit University into a Green University, guided by the principles of Green U and the United Nations Sustainable Development Goals (SDGs). The research focused on improving the efficiency of energy consumption, waste management, and water resource utilization, while cultivating a strong culture of environmental responsibility among students and staff. A qualitative approach was employed, utilizing in-depth interviews with key stakeholders alongside a systematic review of documents and existing research related to Green University development. The findings indicated that transitioning Kasem Bundit University into a Green University can substantially reduce environmental impacts, lower operational costs, and foster environmentally responsible behaviors within the university community. The study proposed key recommendations, including the adoption of an integrated energy management plan, the implementation of effective waste segregation and recycling systems, and the promotion of sustainable water use practices. The results underscore the importance of systems thinking and institutional collaboration in implementing sustainable policies that adhere to international standards. The proposed model serves not only as a roadmap for Kasem Bundit University but also as a replicable guideline for other institutions of higher education aiming to achieve sustainability both locally and globally.

Keywords: Green University, Sustainable Development Goals (SDGs), UI Green Metric,

Introduction

Public policy frameworks supporting sustainable development and environmental impact reduction have gained increasing global importance. The United Nations (UN) launched the

Sustainable Development Goals (SDGs) in 2015, setting 17 objectives to be achieved by 2030. These goals address critical global challenges, including poverty eradication, quality education, public health, and environmental conservation (United Nations, 2015). For higher education institutions, the SDGs offer a strategic foundation for integrating sustainability principles into institutional development.

In addition, the UI GreenMetric World University Rankings serve as a widely accepted global benchmark to assess universities' commitment to sustainability. This ranking system evaluates key indicators such as energy and climate change, waste and water management, transportation, and environmental education (UI GreenMetric, 2020). These indicators encourage universities to adopt environmentally and socially responsible practices, aligning their missions with global sustainability imperatives.

The concept of Green **University** has emerged as a transformative policy initiative recognized worldwide. It reflects a university's ability not only to minimize environmental impacts but also to contribute to sustainable economic and social development. Green Universities also act as hubs of innovation and collaboration, fostering partnerships among academic institutions, local communities, and policymakers.

In the context of global environmental challenges—ranging from industrialization and urbanization to climate change, universities play a critical role in shaping sustainable futures. They are uniquely positioned to disseminate knowledge, build awareness, and empower future generations to address sustainability issues (Lozano et al., 2015). Transitioning toward a Green University model not only enables resource conservation and cost reduction but also enhances institutional credibility and promotes sustainable practices in the broader community (Shuwaikh & Abubakar, 2008).

Kasem Bundit University has officially adopted a policy to pursue Green University status by aligning with the Green U principles and the SDGs. The initiative seeks to foster a sustainable environment by promoting energy efficiency, responsible waste and water management, biodiversity enhancement, and reduced greenhouse gas emissions. These practices aim to reduce the environmental footprint of the campus while building awareness and responsible behavior among students, faculty, and staff.

Implementing a Green University strategy brings significant institutional benefits. It results in cost savings through

improved energy and resource efficiency, while simultaneously cultivating a culture of environmental stewardship (Cortese, 2003). On a broader scale, it enables the university to participate in global sustainability networks and to serve as a model for other institutions—both in Thailand and internationally.

To achieve this transformation, a clear strategic framework and set of operational standards are necessary. This study seeks to develop such a framework for Kasem Bundit University, rooted in internationally recognized guidelines, particularly the Green U framework and UI GreenMetric indicators. These frameworks promote systemic change in university governance by integrating sustainability into planning, operations, research, and academic curricula.

By establishing evidence-based sustainability practices, the university can promote long-term institutional transformation. These practices include structured energy management, effective waste reduction, optimized water use, and enhanced environmental education and awareness. In doing so, Kasem Bundit University not only enhances its sustainable development credentials but also contributes meaningfully to national policy goals and the global SDGs.

Ultimately, this research contributes to defining a practical, scalable model for sustainable university development. It reinforces Kasem Bundit University's role as a leader in sustainability and its capacity to inspire replication and adaptation across other higher education institutions in Thailand and beyond.

Research Objectives

1. To design an integrated and actionable framework that supports Kasem Bundit University in its transition toward becoming a Green University, aligning with the Green U indicators and the United Nations Sustainable Development Goals (SDGs).

2. To improve the university’s operational efficiency through evidence-based strategies for energy management, waste management, and water resource utilization, ensuring measurable reductions in environmental impact.

3. To promote environmental literacy and foster a university-wide culture of sustainability among students, faculty, and staff, thereby enhancing long-term behavioral change and institutional commitment to sustainability.

4. To position Kasem Bundit University as a model of sustainable higher education in Thailand, while contributing to global sustainability efforts through adherence to SDG targets and international green university standards

Scope of the Research

1. Content Scope This research focuses on developing a strategic and practical framework to guide Kasem Bundit University toward becoming a Green University, based on the indicators of the UI Green Metric World University Rankings **and the** United Nations Sustainable Development Goals (SDGs)**.** The study will assess and integrate sustainable practices in the following core areas:

Energy management (e.g., use of renewable energy and energy-saving technologies), Water resource utilization (e.g., water conservation systems and reuse of non-potable water), Waste management (e.g., waste segregation, recycling programs), Environmental awareness and engagement (e.g., sustainability education, student/staff participation), Sustainable campus infrastructure and green spaces (e.g., building design, open space development).

The scope also includes the examination of policies, stakeholder engagement, and institutional readiness, with an emphasis on a holistic management approach to sustainability.

2. Geographical Scope The research will take place within the campuses of Kasem Bundit University**,** particularly the Romklao Campus. It will cover physical infrastructure and operational systems, including:

Academic buildings and classrooms, Administrative and office spaces, Sports facilities and green areas, Dormitories, cafeterias, and service areas. This ensures that environmental and sustainability issues are studied in an integrated, cross-functional way across all university functions and spatial domains.

3. Time Scope The research is scheduled for a 12-month period (October 2023 to September 2024), and will include:

Phase 1 (Months 1–6): Literature review, policy analysis, and both quantitative and qualitative data collection through interviews, document analysis, and on-site observations.

Phase 2 (Months 7–8): Data synthesis and content analysis using thematic and comparative methods.

Phase 3 (Months 9–12): Model and guideline development, validation with stakeholders, and preparation of policy recommendations

Benefits of the Research

1. The research will result in a comprehensive and adaptable framework that enables Kasem Bundit University to operationalize the Green University model, enhancing sustainability across academic, administrative, and infrastructural domains.

2. It will improve resource efficiency, particularly in energy, water, and waste management, leading to reduced environmental impacts and long-term cost savings.

3. It will foster a culture of environmental responsibility and enhance environmental literacy among students, faculty, and staff through participatory learning and engagement.

4. It will support institutional positioning and recognition at both the national and international levels, strengthening the university's profile as a leader in sustainability-driven higher education.

5. The outcomes and recommendations can be replicated or adapted by other universities seeking to align with Green U or SDG frameworks, thereby contributing to wider educational sustainability movements in Thailand and globally.

Literature Review

1. Concept of Green University Development The concept of a Green University refers to higher education institutions adopting sustainable practices in campus operations, governance, and education to reduce negative environmental impacts. This involves energy efficiency, sustainable water usage, waste reduction, and fostering environmental responsibility among students and staff (Alshuwaikhat & Abubakar, 2008). A Green University also integrates sustainability into curricula and research while serving as a model for broader community development.

2. Theoretical Foundations

Sustainable Development Theory The Brundtland Commission (1987) defined sustainable development as "development that meets the needs of the present without compromising the **ability** of future generations to meet their own needs." This theory underpins the United Nations' Sustainable Development Goals (SDGs), offering a universal framework that universities can use to design strategies that balance environmental, social, and economic development (United Nations, 2015).

Systems Theory Systems theory views the university as a set of interconnected subsystems (e.g., buildings, waste, energy, people) working together toward a sustainable goal (Meadows, 2008). This theory supports holistic approaches to planning, helping institutions understand feedback loops, synergies, and the long-term implications of environmental decisions (Cortese, 2003).

Social Learning Theory Social learning theory emphasizes the role of modeling and experiential engagement in shaping pro-environmental behavior.

Within Green Universities, students and staff can internalize sustainable behaviors through participation in real-world environmental initiatives and peer-led activities (Bandura, 1977).

3. Related Research and Indicators Lozano et al. (2015) emphasize that sustainability in universities must be integrated across institutional strategies, curricula, operations, and partnerships. Their study presents a model for aligning institutional practices with global sustainability frameworks like the SDGs.

The UI GreenMetric World University Rankings (Universitas Indonesia, 2020) is a global benchmarking tool that assesses universities across indicators such as setting and infrastructure, energy and climate change, waste, water, transportation, and education. This index has played a key role in promoting sustainability reporting and competition among institutions worldwide.

4. Case Studies of Green Universities University of Tokyo (Japan): Developed the "Action Plan for a Carbon-Free Campus" with a focus on solar energy, smart energy monitoring, and biodiversity restoration (University of Tokyo, 2020).

University of Copenhagen (Denmark): Set a target to cut carbon emissions by 65% by 2030, integrated sustainability into research and curriculum, and promoted green mobility (University of Copenhagen, 2019).

Monash University (Australia): Implemented the “Net Zero Initiative” featuring solar farms, smart energy grids, water reuse, and waste minimization strategies (Monash University, 2018).

University of California, Davis (USA): Achieved multiple LEED-certified buildings and installed a 14-megawatt solar farm for clean energy (University of California, Davis, 2020).

University of Nottingham (UK): Adopted comprehensive strategies including green construction, biodiversity zones, and waste minimization (University of Nottingham, 2020).

Mahidol University (Thailand): Topped UI Green Metric rankings in Thailand through solar energy, LED systems, and waste segregation programs (Mahidol University, 2021).

These case studies provide valuable models demonstrating how different cultural and regional contexts adapt sustainability frameworks effectively.

Research Methodology

This study employed a qualitative research methodology designed to explore and analyze processes, policies, and practices essential for transforming Kasem Bundit University into a Green University. The methodology is guided by the UI Green

Metric indicators and the United Nations Sustainable Development Goals (SDGs) framework, emphasizing sustainability in higher education institutions.

1. Research Design

The research follows a case study approach, which allows an in-depth examination of Kasem Bundit University's current practices, strengths, and areas for development in relation to sustainable university management. This design is appropriate for understanding complex systems and contextual dynamics related to environmental management in higher education.

2. Data Collection Methods

To gather rich and contextual data, the study applied the following qualitative techniques:

In-depth Interviews: Conducted with key stakeholders including university administrators, facilities management personnel, academic staff, and student representatives. These interviews aim to explore perceptions, institutional strategies, and operational challenges in implementing sustainable practices.

Document Analysis: reviews of internal reports, sustainability policies, Green U guidelines, SDG implementation strategies, and relevant university documents. These sources provide baseline data and insights into the university's current environmental performance.

On-site Observations: Conducted in various locations such as classrooms, green spaces, waste collection points, and energy use areas. This helps to validate data from interviews and documents through direct engagement with the physical environment.

3. Data Analysis

The collected data were analyzed through thematic content analysis, involving:

Coding interview transcripts and documents to identify recurring themes related to energy use, waste and water management, environmental awareness, and policy frameworks.

Triangulation of data sources (interviews, documents, and observations) to ensure credibility and validity.

Comparing findings against UI Green Metric criteria and SDG targets to assess alignment and identify gaps.

4. Research Duration and Scope

The research was conducted over a 12-month period from October 2023 to September 2024, encompassing all operational and academic zones of Kasem Bundit University, including administrative buildings, student facilities, classrooms, and recreational areas

Synthesis of Research Findings

Based on the data collected through interviews, document analysis, and observations, the study synthesized key findings into a comprehensive framework

for developing Kasem Bundit University into a Green University. The synthesis focused on four core operational dimensions:

1. Energy Management – Including the adoption of renewable energy technologies, energy-saving policies, and infrastructure optimization.
2. Water Resource Utilization – Incorporating water-saving technologies, efficient irrigation systems, and water reuse strategies.
3. Waste Management – Implementing systematic waste separation, promoting recycling, and reducing single-use materials.
4. Environmental Awareness and Culture – Fostering sustainability consciousness through student and staff engagement, training programs, and environmental campaigns.

These synthesized elements contribute to the formation of a practical development framework aligned with the UI Green Metric indicators and the United Nations Sustainable Development Goals (SDGs). The framework provides actionable guidelines for university administrators and stakeholders to implement sustainability practices at institutional and operational levels.

Research Findings

The research revealed several critical insights:

1. Institutional Readiness Kasem Bundit University has demonstrated a foundational commitment to sustainability, as seen in its existing policies and stakeholder awareness. However, gaps remain in implementation consistency, particularly in infrastructure upgrades and integrated sustainability planning.
2. Potential for Resource Efficiency The university can significantly improve its energy, water, and waste efficiency by adopting green technologies and optimizing existing systems. Such improvements will lead to reduced environmental impact and operational cost savings in the long term.
3. Cultural Transformation as a Key Enabler Building a culture of environmental responsibility among students and staff emerged as a central success factor. Environmental education, training programs, and role modeling by university leaders are essential to instill sustainable behaviors.
4. Holistic Management is Essential A systems-based approach that integrates sustainability into all aspects of university operations—administration, curriculum, facilities, and community engagement—is necessary for effective transformation into a Green University.
5. Scalability and Replicability The framework and lessons derived from this study offer a viable model for other

institutions seeking to align with international sustainability standards. It also supports Thailand's national policies on environmental responsibility in higher education and contributes to the broader achievement of the SDGs.

Conclusion and Discussion

The findings of this study confirm that transforming Kasem Bundit University into a Green University—guided by the UI Green Metric indicators and the Sustainable Development Goals (SDGs)is both feasible and impactful when approached through strategic, integrated measures. These include energy efficiency, sustainable water resource use, systematic waste management, and the promotion of an environmental conservation culture within the university community.

Importantly, the study reveals that the concept of a Green University is not merely about environmental protection but involves redefining institutional management practices to achieve long-term sustainability. Measures such as adopting renewable energy, implementing water-saving technologies, and promoting waste reduction initiatives contribute not only to lowering environmental impact but also to reducing operational costs. These findings align with the Sustainable Development Theory (Brundtland Commission, 1987), which advocates optimizing current resource use without compromising future needs.

Additionally, the Systems Theory perspective (Meadows, 2008) supports the research's holistic approach—viewing the university as an interrelated system. Success in one domain (e.g., energy efficiency) influences and supports improvements in others (e.g., cost savings and campus culture), reinforcing the idea that sustainable development must occur across all university functions, not in silos.

From the lens of Social Learning Theory (Bandura, 1977), the findings underscore the importance of modeling sustainable behaviors, engaging stakeholders in practical initiatives, and fostering peer learning. The study found that environmental awareness campaigns, participatory training, and student involvement play a key role in shifting attitudes and fostering behavioral change.

Despite the clear benefits, the research identifies a major challenge: transforming organizational culture and ingrained behaviors. Establishing a Green University demands continuous effort, long-term vision, and supportive leadership. Institutional resistance, limited awareness, and a lack of integrated policy frameworks can slow progress. Therefore, successful implementation requires:

Consistent institutional policy support, both internally and from government agencies.

Resource investment in infrastructure, such as renewable energy systems and water conservation technology.

Engagement strategies that empower faculty, staff, and students to become change agents.

The research offers a replicable framework for other universities, especially in Southeast Asia, to follow. Kasem Bundit University's case highlights how localized sustainability practices can contribute to global sustainability agendas. The study affirms that higher education institutions are not only centers of learning, but also models of sustainable behavior, capable of influencing their surrounding communities and society at large.

Theoretical Recommendations

The findings of this research suggest that the transformation of a university into a Green University not only improves resource management efficiency but also fosters an institutional culture of environmental awareness and responsibility. In line with this, the following theoretical frameworks are recommended to guide and support sustainable development within higher education institutions:

1. Systems Theory as a Framework for Integrated Environmental Management Systems Theory (Meadows, 2008) offers a holistic approach to understanding how different subsystems within a university—such as energy consumption, waste disposal, and water management—interact and influence one another. By applying this perspective, universities can move beyond fragmented management strategies and adopt integrated planning that recognizes the interdependence of various environmental components. This systemic view enables institutions to anticipate unintended consequences, optimize resource flows, and design more resilient sustainability initiatives.

2. Sustainable Development Theory to Shape Long-Term Institutional Vision Rooted in the Brundtland Commission's definition (1987), Sustainable Development Theory emphasizes meeting present needs without compromising future generations. This theory provides a normative foundation for universities to align their operational policies, infrastructure investments, and academic programs with sustainability principles. It encourages long-term planning and responsible resource consumption, helping institutions embed sustainability goals into their strategic vision and governance frameworks.

3. Social Learning Theory to Foster a Culture of Environmental Responsibility Based on Bandura's (1977) Social

Learning Theory, behavior change within institutions can be effectively promoted through observation, modeling, and participation. Universities should intentionally cultivate an environment where sustainable behaviors are demonstrated by faculty, staff, and student leaders. Environmental programs that involve experiential learning, peer-to-peer influence, and visible role models can reinforce positive habits and transform sustainability from policy into everyday practice. This theory is particularly effective in fostering collective engagement and shaping long-term values among members of the university community.

Implications for Institutional Development

These three theoretical perspectives—Systems Theory, Sustainable Development Theory, and Social Learning Theory—complement one another and provide a robust foundation for institutional change. When applied in combination, they enable universities to:

Strategically design sustainability programs that consider system-wide interactions.

Anchor sustainability in policy, planning, and academic missions.

Nurture a campus-wide culture that supports and sustains behavioral change.

Together, these theories can serve as a model framework for other institutions seeking to develop effective, evidence-based approaches toward becoming Green Universities and contributing to global sustainability goals.

Practical Recommendations

Based on the research findings, the following practical recommendations are proposed to guide Kasem Bundit University in its transition toward becoming a Green University in accordance with UI Green Metric and the Sustainable Development Goals (SDGs):

1. Establish a Strategic Energy Management and Monitoring System Develop an institutional energy management policy that includes the installation of energy-efficient technologies, such as LED lighting, motion-sensor lighting systems, and solar energy systems. Establish a centralized digital monitoring system to collect real-time energy usage data across university facilities. This enables continuous analysis, benchmarking, and improvement of energy efficiency performance while contributing to the reduction of carbon emissions.

2. Implement Campus-Wide Integrated Waste Management Programs: Design a waste management system that includes source separation (e.g., organic, recyclable, hazardous waste) with clearly marked disposal stations across the campus.

Launch awareness campaigns and educational signage to promote responsible waste disposal behaviors among students and staff. Incorporate digital tracking of waste volumes and types to monitor progress and identify areas for improvement.

3. Adopt Water Efficiency and Conservation Infrastructure Install low-flow water fixtures, automatic faucets, and water-efficient sanitation systems across all university buildings. Introduce rainwater harvesting systems for landscape irrigation and explore the use of greywater systems for non-potable applications. Conduct campus-wide training on water conservation practices and display water usage data in public areas to encourage behavioral change.

4. Promote Sustainability Education and Campus Engagement: Integrate sustainability content into the university curriculum across faculties and offer interdisciplinary elective courses on environmental issues. Establish student-led Green Campus Clubs and organize ongoing activities such as eco-hackathons, zero-waste campaigns, and monthly "Green Action Days." Provide incentives and recognition for sustainable behavior, including a "Green Ambassador" program for students and staff.

5. Strengthen Institutional Collaboration and Knowledge Exchange. Form formal networks with local and international universities, environmental NGOs, and government agencies to foster exchange of best practices, joint research, and co-hosted sustainability conferences. Collaborate on green pilot projects and invite external experts to evaluate and improve campus sustainability strategies. Participation in international platforms such as UI Green Metric and AASHE STARS should be encouraged for benchmarking and visibility.

These recommendations emphasize both technological implementation and behavioral transformation, ensuring that sustainability becomes embedded in the university's daily operations and culture. By institutionalizing these practices, Kasem Bundit University can establish itself as a regional model for Green University transformation and contribute meaningfully to the achievement of the SDGs.

Future Research Recommendations

1. Broaden Comparative Studies: Future research should include multiple universities, both domestic and international, to compare Green University development approaches and extract best practices for contextual adaptation.

2. Assess Economic Impacts Further studies should explore the long-term economic benefits of Green University initiatives, including cost

savings, funding opportunities, and value-added institutional branding.

3. Examine Environmental Behaviors Investigate the environmental attitudes and behaviors of students and staff to identify engagement factors that influence the success of sustainable campus initiatives.

4. Develop Localized Indicators Future research should formulate environmental performance indicators tailored to Thailand's cultural and ecological context to improve measurement and policy relevance.

5. Leverage Digital Technology Explore the application of digital tools (e.g., IoT, big data analytics) to enhance environmental monitoring, management efficiency, and data-driven decision-making within university systems.

Practical Recommendations for Developing Kasem Bundit University into a Green University

To advance Kasem Bundit University toward becoming a Green University, a series of integrated and actionable sustainability strategies should be adopted. In terms of energy management, the university should prioritize the installation of energy-efficient technologies, such as LED lighting and automated controls, coupled with renewable energy sources like solar panels. A centralized energy monitoring system is also essential to improve operational efficiency and reduce carbon emissions. Despite high initial costs and the need for technical expertise, this initiative can be supported by awareness-building workshops and the creation of student-led energy clubs to foster broad participation.

For waste management, the implementation of a source-segregated waste system—including designated bins for recyclables and organic waste—must be supported by campus-wide education on proper disposal practices. Engagement campaigns, such as zero-waste competitions and green product promotions, can help embed recycling behavior into daily routines. However, sustained cooperation and institutional infrastructure remain critical to long-term success.

Water conservation efforts should focus on installing water-saving fixtures and introducing rainwater harvesting systems for landscape irrigation. Promoting responsible water use through posters, social media, and student-led campaigns can build awareness and behavioral change. Although initial investments may be a constraint, these practices offer long-term cost savings and environmental benefits.

Cultivating a culture of environmental conservation is equally vital. This involves organizing participatory activities such as Green University Day, eco-project

contests, and hands-on sustainability learning programs like tree planting and waste audits. Challenges such as limited motivation or resources can be mitigated by forming environmental clubs and communication channels that empower both staff and students to take ownership of initiatives.

Finally, institutional collaboration is key. Building partnerships with other universities, NGOs, and governmental agencies can enhance knowledge exchange and joint sustainability efforts. While resource limitations may constrain collaboration, strategic networking and participation in academic conferences can open up new pathways for innovation and support

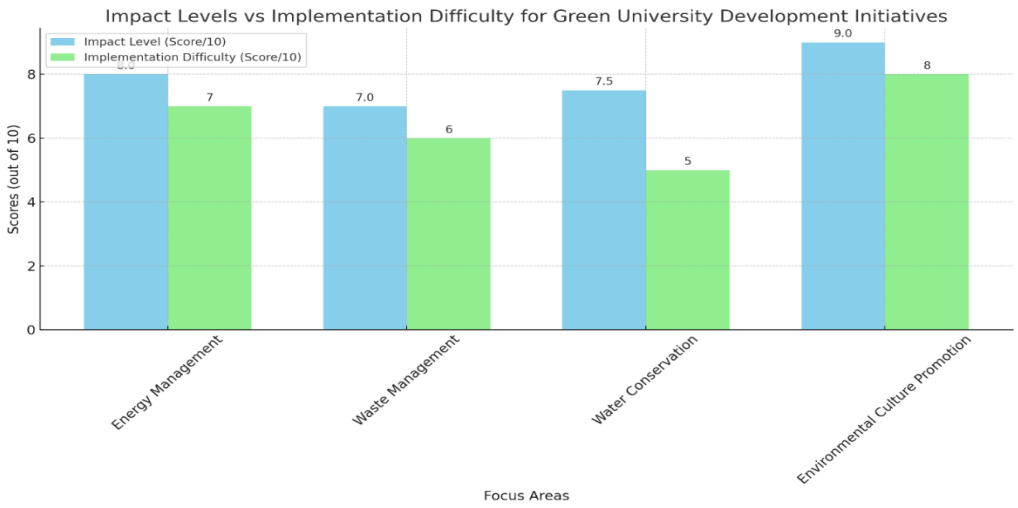

Figure 1: Comparison of Impact Levels and Implementation Difficulty Across Key Green University Development Focus Areas

The chart titled "Impact Levels vs Implementation Difficulty for Green University Development Initiatives" illustrates a comparative analysis of four key focus areas: Energy Management, Waste Management, Water Conservation, and Environmental Culture Promotion. Each area is assessed using two criteria: Impact Level and Implementation Difficulty, both measured on a scale from 1 to 10.

Key Observations:

1. Environmental Culture Promotion stands out with the highest impact level (9.0) but also reflects a high implementation difficulty (8.0). This suggests that while cultural transformation yields substantial long-term benefits in

sustainability, it requires significant effort, resources, and sustained engagement from the university community.

2. Water Conservation demonstrates a favorable impact-to-difficulty ratio, with a high impact score (7.5) but the lowest difficulty score (5.0) among all categories. This implies that water conservation initiatives may offer a "quick win" with relatively lower barriers to implementation, making it an ideal starting point for institutional change.

3. Energy Management scores 8.0 in impact and 7.0 in difficulty, indicating that although the benefits are considerable, such as cost savings and carbon reduction, the operational complexity and investment requirements are moderate to high.

4. Waste Management ranks 7.0 in impact and 6.0 in difficulty, reflecting a balanced opportunity where structured policies and community engagement can drive sustainable waste behavior with manageable implementation challenges.

Strategic Implications:

Prioritization: Based on this comparison, the university may prioritize Water Conservation and Waste Management in the short term to build momentum and showcase measurable success.

Long-Term Focus: Environmental Culture Promotion should be treated as a strategic long-term goal requiring dedicated leadership, incentive mechanisms, and integration with educational programs.

Systemic Integration: All four areas are interrelated and should be implemented as part of a broader systems approach aligned with the UI Green Metric indicators and SDGs.

Data Source and Reliability:

The scores presented are based on expert interviews, institutional observations, and content analysis of policy documents. To enhance validity, triangulation was applied across data sources, and interpretations were reviewed against existing best practices in Green University initiatives.

Policy Matrix for Green University Development

This policy matrix provides a strategic overview of the five key areas essential to developing Kasem Bundit University into a Green University. It outlines the corresponding actions, enabling and hindering factors, and strategies for engaging stakeholders to ensure successful and sustainable implementation

Table 1: Policy Matrix for the Development of Kasem Bundit University into a Green University

Strategic Area	Key Actions/Policy Direction	Supporting Factors	Challenges/Barriers	Community Engagement Strategy
1. Sustainable Energy Management	Implement LED lights, solar panels, and energy monitoring systems	Institutional support; availability of technology	High initial cost; technical maintenance	Seminars, student energy clubs, awareness campaigns
2. Efficient Waste Management	Introduce waste segregation, reduce packaging, promote reuse/recycle	Existing waste facilities; environmental campaigns	Behavioral resistance; lack of enforcement	Recycling competitions, awareness workshops, student clubs
3. Sustainable Water Resource Utilization	Water-saving fixtures, rainwater harvesting, reduce water use	Availability of space; awareness of water scarcity	Investment costs; usage habits	Poster campaigns, contests, green idea sharing
4. Environmental Conservation Culture	Green events, participatory projects (e.g., tree planting, green days)	University mission alignment; interest groups	Low student/staff motivation; time limitations	Volunteer networks, student-led green initiatives
5. Networking and Collaboration	Partner with NGOs, government, and other Green Universities	Shared goals, policy incentives	Resource constraints; inconsistent cooperation	Joint activities, collaborative research, knowledge excha

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Visions of Bulgarian urban futures: applying the Literary Method of Urban Design

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ABSTRACT

This article explored the application of the Literary Method of Urban Design to three Bulgarian cities—Plovdiv, Veliko Tarnovo, and Ahtopol—by drawing upon local and national literary works to envision these cities future development. Through a three-step process, the method selects novels that reflect each city's cultural, historical, and environmental identity, extracts thematic elements from the narratives, and projects these themes onto speculative urban futures before displaying the results as lively scenario art. Using Anton Donchev's *Time of Parting* for Plovdiv, Emilian Stanev's *The Peach Thief* for Veliko Tarnovo, and Zdravka Evtimova's *Vassil* for Ahtopol, the article demonstrates how fiction can guide urban planning and futuring. Common themes, such as the integration of nature into urban life and the preservation of cultural heritage, emerge across these three case study Bulgarian cities. However, the unique challenges faced by each city—be they social, environmental, or economic—are also highlighted, perhaps illustrating the method's flexibility in addressing specific urban issues. The article emphasizes the pedagogical potential of this method for students of design, geography, and literature, offering a multidisciplinary approach that fosters creative thinking and critical engagement with urban challenges. Ultimately, the Literary Method of Urban Design showcases how fiction can inspire innovative, sustainable, and inclusive cityscapes for the future.

Keyword: futurity, cities, literary, urbanism, Bulgaria, Europe

Introduction

In applying the Literary Method of Urban Design to Bulgarian cities, this article embarks on a journey through three distinct urban landscapes, each inspired by a seminal literary work. This method involves a three-step process, whereby novels that capture the cultural, historical, and environmental character of a place are analyzed and then creatively projected onto future urban scenarios. The intent is to bridge the narrative world of fiction with the potential realities of distant urban planning, allowing the nuances of storytelling to inform visionary urban designs. Some writers have attempted cultural deconstructions of historical imaginaries of Bulgarian urban settings (see for example, Kaneva, 2007, Todorova, 2009, or Radev, 2010) but this paper attempts an artistic reconstruction based upon local literary inspiration (rather than a cultural deconstruction).

The three steps can be conceptualized as follows (see diagram one). As you see, the steps lead to the presentation of a textual and graphic scenario.

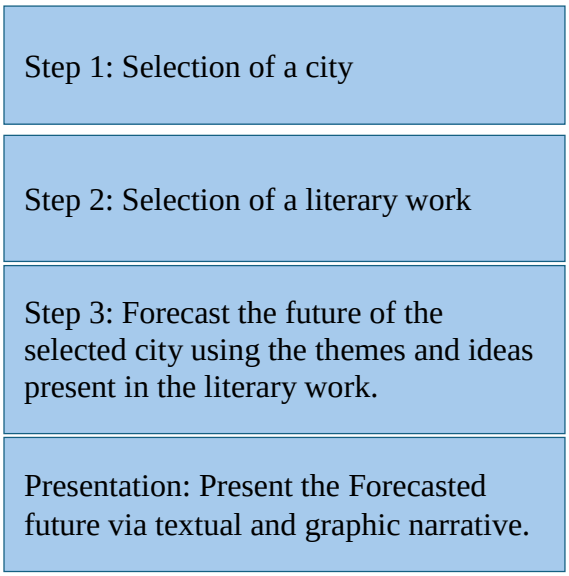

Diagram 1. A top-to-bottom linear conceptualization of the Literary Method of Urban Design.

The first step in this method requires the identification of a novel or literary work that captures key themes resonant with the city's historical and cultural identity. This work serves as the lens through which the city's current challenges — be they environmental, social, or economic — are examined. In this article, three Bulgarian cities, Plovdiv, Veliko Tarnovo, and Ahtopol, are examined through the works of Anton Donchev, Emilian Stanev, and Zdravka Evtimova, respectively. These novels, selected for their rich narrative exploration of identity, conflict, longing, and connection to nature, offer deep insights into the future trajectories of these urban areas.

The second step involves an in-depth analysis of the chosen literary work to

extract themes, symbols, and narratives that can be transposed onto the city's urban fabric. For example, Anton Donchev's *Time of Parting*, with its focus on religious and cultural tensions / interactions, inspires a future vision of Plovdiv as a city that reconciles its diverse past through inclusive urban spaces and ecological regeneration (whilst also referencing the social / cultural vexations caused by the Great War, as covered by the likes of Miller, 1983). Similarly, Stanev's *The Peach Thief* invites a reimagining of Veliko Tarnovo as a city that economic growth with environmental sustainability, while Evtimova's *Vassil* lays the groundwork for transforming Ahtopol into a nature-loving town closely connected to Strandzha Nature Park.

The final step involves the projection of these literary-inspired themes onto a speculative future for each city. This step fuses fiction with pragmatic urban design and scenario art elements, proposing cities that not only preserve their cultural heritage but also embrace sustainability, resilience, and inclusivity. Plovdiv might evolve into a hub of cultural exchange along its restored urban woodlands and dense apartment blocks; Veliko Tarnovo could become a resilient riverine city with eco-tourism and green infrastructure at its core; and Ahtopol may thrive as a model of biophilic design, blending its historic architecture with nature-centered urban aspirations.

Through this process, the Literary Method of Urban Design envisions Bulgarian cities of the future as places where literature, art, nature, and urbanism converge, guiding their transformation into spaces that honor their past while preparing for the environmental and social challenges of tomorrow.

1. Case Study One: The Future of Plovdiv as Inspired by Donchev's *Time of Parting*

The novel *Time of Parting* by Anton Donchev (1964) explores the deep religious and cultural conflicts between different Christians and Muslims in Ottoman-ruled Bulgaria (for more history on this, see Crampton, 2005; Cremin, 2013; Bechev, 2019). Set in the Rhodope Mountains, near Plovdiv, the novel delves into themes of identity, loyalty, and the painful process of change. Plovdiv, as one of the oldest cities in Europe and a historically significant crossroads of cultures (as explored in Radev, 2010), is an ideal candidate for an urban design fiction based on these themes.

In a future scenario inspired by *Time of Parting* – see figure one – Plovdiv would become a city that grapples with questions of identity and coexistence, finding ways to

embrace its diverse historical legacies while addressing modern social and environmental challenges. The novel's exploration of the tensions between different religious and cultural groups can be reflected in a city that fosters unity through diversity, creating spaces for dialogue and cultural exchange.

Figure 1 The Future of Plovdiv (by the author) inspired by Donchev's *Time of Parting*

Plovdiv is often referred to as the "City of Seven Hills" due to its unique geographical landscape, built upon seven syenite hills. These hills historically shaped the city's cultural and architectural identity, making it a symbol of continuity between ancient Thracian, Roman, and Bulgarian eras. Figure one depicts a futuristic vision of Plovdiv's architecture on one of these hills, blending Christian domed building motifs with the Balkan-style extended family housing of the late 19th century (a style outlined by Todorova, 1996 and Cremin, 2013) whilst making a nod to the ecofriendly nature of pedestrianism and the regeneration of urban woodlands. The buildings stand integrated with the natural rock formations, harking back to pre-Slavic Bulgaria, and are adorned with greenery that merges the urban landscape with the various

woodland and forest zones of the nearby mountain ranges, symbolizing a future where sustainable living and historical heritage coexist (in the vein advocated by Rees, 1995, Newman & Kenworthy, 1999), Register, 2006, and Lehmann, 2010). The depiction highlights the potential of Plovdiv's hills to support eco-architecture that embraces the natural environment while maintaining the city's iconic aesthetic The depiction also suggests that if the city can embrace its pre-Slavic roots, it can also turn the page on Slavic – Turkish relations (which Donchev's novel so vividly describes in brutal clarity), since the 19th century Bulgarian architecture in figure one is also redolent of -- and contiguous with – similar 19th century Ottoman architecture.

Plovdiv's future, inspired by the natural landscapes of the nearby Rhodope Mountains (written about by Donchev), would be one where the city reconnects with its surrounding environment. The Maritsa River, which flows through Plovdiv, would become a focal point for environmental regeneration. Riverbank restoration projects would play a key role in transforming the river from a polluted industrial zone into a vibrant ecological corridor (also see case study two, below). This space would serve both environmental and social purposes, providing areas for recreation, cultural festivals, and open-air markets that reflect the city's diverse traditions.

Urban agriculture and permaculture practices could also be central to Plovdiv's environmental future (as proposed for other cities by Lehmann, 2010). Drawing on the agricultural imagery in *Time of Parting*, this vision would see the city's residents reclaiming abandoned waste spaces for community gardens and food forests. These projects would not only address food security but also promote sustainability and self-reliance, echoing the novel's themes of resilience in the face of adversity.

Plovdiv's future would also be shaped by the novel's exploration of identity and conflict. In a city with a long history of religious and cultural conflict / diversity (on the history of such, see: Kosev, 1969; Todorova, 1996, Mazower, 2004; Crampton, 2005; Daskalov, 2011), Plovdiv would become a model for peaceful coexistence. Inspired by the novel's occasional utterances toward dialogue and understanding, the city could establish cultural centers dedicated to fostering dialogue between different religious and ethnic groups. These centers would host events, workshops, and exhibitions that celebrate Plovdiv's diverse history while promoting tolerance and

mutual respect (which have at times been recipes of success in the development and prosperity of other Balkan cities over centuries past (see Glenny; 1999, and Hupchick, 2002).

Politically, Plovdiv could experiment with a form of governance that prioritizes inclusivity and dialogue. Just as likely though, if we extend into the future the tensions in the novel, there will be a growth in ethno-nationalism as Bulgarian Slavs assert their control to marginalize or push put the influence of the town's remaining Turkish or Muslim inhabitants. Which type of governance will prevail into the late 21st century can not be known now but hopefully, with the continued rise of liberal ideas coming in from Bulgaria's EU partners, local councils would be structured according to cosmopolitan European ideals to ensure representation from all the city's diverse communities. This would work to ensure that decisions reflect the interests and values of the entire population. The city's future would be one where differences are not only tolerated but celebrated, and where citizens are actively engaged in shaping the future of their communities.

2. Case Study Two: The Future of Veliko Tarnovo As Inspired by Stanev's *The Peach Thief*

In the case of Veliko Tarnovo, one of Bulgaria's most historically significant cities, the novel *The Peach Thief* by Emilian Stanev (1965) can be employed to project a future that is not only steeped in its past but also responsive to its socio-environmental evolution. *The Peach Thief* revolves around themes of moral conflict, the human spirit's resilience, and the quest for freedom during times of hardship. Set in World War I, the novel depicts the relationship between a Bulgarian woman and a Serbian prisoner of war, challenging societal and national boundaries.

This story conveys a strong sense of personal and collective struggle, as well as loss, love, and resilience. Applying these themes to Veliko Tarnovo allows urban planners to consider how the town's past struggles — as well as its history as the medieval capital of the Second Bulgarian Empire and its revolutionary roles in the Modern Period (see Kosev, 1969, Todorova, 1996, and Baeva, 2011, Daskalov, 2011) — can inform a forecast of the city's future urban development.

A major thematic concern in *The Peach Thief* is the tension between individual desires and societal constraints. For Veliko Tarnovo, this tension could be interpreted as the need to balance the

preservation of historical heritage with the desire for modern urban expansion and sustainability. The city's iconic architecture, such as Tsarevets Fortress, represents its deep connection to national identity and collective memory, yet the desire for development and modernization creates an inevitable conflict. Drawing from the novel, urban designers could prioritize a future where Veliko Tarnovo becomes a city that honors its past through adaptive reuse. The preservation of historical buildings could be paired with innovative green technologies, such as solar energy, to integrate sustainable living into the town's medieval structures, reflecting the resilience that runs through Stanev's narrative.

Another key aspect of *The Peach Thief* is the subversion of boundaries, be they national, moral, or personal. Veliko Tarnovo's future can take inspiration from this idea by promoting a sense of openness and inclusivity in its urban design. The novel highlights the transformative potential of human relationships that transcend political divisions, offering a framework for a more globally connected Veliko Tarnovo. As Bulgaria continues to engage with international markets and the European Union, the city can anticipate a cosmopolitan future that welcomes diverse cultural influences while maintaining a softer version of its unique identity. A focus on creating shared public spaces — such as riverside plazas, civic parks, community centers, and cultural hubs—could foster this sense of openness, encouraging interaction across national, ethnic and social boundaries.

In addition, *The Peach Thief* places great emphasis on human connection with natural beauty. This relationship with nature suggests that Veliko Tarnovo could embrace a greener, more ecofriendly future, where urban planning respects the natural landscape (see figure two). The steep hills and meandering Yantra River that define the town’s geography could play a central role in a vision for an ecologically sustainable city. Creating green corridors, enhancing internationally-renown public gardens, and promoting pedestrian-friendly pathways along the river can help the city harmonize with its natural environment, reflecting the novel’s underlying themes of nurturing and survival

Figure 2 The Future of Veliko Tarnovo (by the author) as inspired by *Stanev's The Peach Thief*

As in other alpine regions of Europe, global warming is accelerating the melting of mountain ice in Bulgaria, particularly in the Rila and Pirin and Balkan ranges, where glaciers and snowpacks are shrinking at unprecedented rates. As temperatures rise, the melting ice contributes to increased water runoff during the warmer months, compounding the effects of climate change. Simultaneously, some seasons in Bulgaria are experiencing more frequent and intense rainfall due to shifting weather patterns, leading to sudden, heavy downpours. These rains, combined with the excessive runoff from melting ice, overwhelm rivers such as the Iskar and Maritsa, causing flash floods that threaten local communities, infrastructure, and agriculture. The compounded impact of rising temperatures and extreme weather is creating a dangerous cycle of flooding and environmental degradation across the country's mountain regions.

The scenario in figure two, though, suggests this extra water energy can be harnessed during floods by special super-flow hydro-mill devices that can be retrofitted (Dixon, *et al* 2014) to convert flood energy into electricity which is then

stored in long-lived batteries to power the town over ensuing months.

Politically, Veliko Tarnovo could adopt a form of governance that prioritizes social inclusion and community well-being. Inspired by the story's focus on personal relationships and hidden desires, the city's future governance could emphasize the importance of personal well-being and emotional health in urban planning. Public spaces would be designed to encourage social interaction and connection, with plazas, parks, and community centers providing opportunities for residents to come together and form meaningful relationships across various age-groups, across various ethnicities, and across various languages (as advocated for other cities by Joss *et al*, 2013).

In conclusion, by using *The Peach Thief* as a lens, Veliko Tarnovo's future can be envisioned as a dynamic blend of tradition, eco-technology, resilience, and changing patterns of sustainability (which has been a recipe for social regeneration in other cities, says Brenner & Schmid, 2014). The Literary Method of Urban Design enables the city to draw on the emotional depth and ethical reflections of the novel to create a future that honors its past, embraces inclusivity, and seeks love for and tolerance of nature

3. Case Study Three: The Future of Ahtopol as Inspired by Evtimova's *Vassil.*

We now come to applying the Literary Method of Urban Design to the future of Ahtopol, a town nestled along Bulgaria's Black Sea coast, through the award-winning short story *Vassil* written by Bulgaria's favorite living writer Zdravka Evtimova (2012). Vassil, with its themes of resilience, connection to the land, and personal renewal, offers a profound narrative to inspire the restoration of Ahtopol as a town deeply linked with the surrounding natural beauty of Strandzha Nature Park (as evidenced in Dimitrov, 2008).

Ahtopol, a small fishing town known for its historic charm and proximity to Strandzha, has the potential to evolve into a biophilic city—a city that weaves nature into its very fabric (see, for example Beatley, 2011), enhancing the well-being of its inhabitants while safeguarding ecosystems. Evtomova's story focuses on themes of perseverance and transformation, with characters grappling with the past and their relationship to place. These ideas can be transposed into urban design, where the restoration and preservation of the natural

environment become central to the town's future (see figure three).

Strandzha Nature Park, located right nearby Ahtopol in southeastern Bulgaria along the Black Sea coast, is the largest protected area in the country. The park is known for its rich biodiversity and unique blend of temperate and Mediterranean ecosystems. Strandzha is also home to ancient forests, wetlands, and diverse landscapes that harbor rare and endemic species of flora and fauna, including the endangered eastern imperial eagle, otters, and an array of bat species (states Dimitrov, 2008). The park also preserves significant cultural heritage, with ancient Thracian sanctuaries, burial mounds, and Slavic and Turkish folkloric traditions intertwined with natural spirits

Strandzha faces several environmental problems that threaten its rich biodiversity and ecosystems. Key issues include illegal logging, which contributes to deforestation and habitat destruction, and unregulated tourism that disrupts wildlife and damages natural landscapes. Additionally, the encroachment of agricultural activities and urban development has led to fragmentation of habitats, putting pressure on endangered species. Pollution from nearby towns, including Ahtopol, plus agricultural runoff also affects the water quality of the park's rivers and wetlands, harming aquatic life. Climate change exacerbates these challenges by altering the park's delicate ecosystems, threatening species' survival and the overall health of the park

Figure 3 The Future of Ahtopol (by the author) as inspired by Evtimova's *Vassil*

Drawing from the values found in *Vassil*, the town of Ahtopol can disengage from the destruction of Strandzha by initiating projects to rewild areas of park (as well as areas of the town) that have suffered from degradation, thereby promoting biodiversity and creating green spaces that seamlessly integrate with urban areas. The town can also push forward to create new eco-tourist resorts and public buildings that are fully sustainable, clean and Green, and provide citizens a way to daily note their ecological surrounds (see figure three). Similar regimes are examined as possibilities for other European cities in Tzoulas, Korpela, & Venn (2007). By embedding green roofs, living architecture, vertical gardens, and tree-lined pathways, Ahtopol would foster a biophilic urban environment that reconnects residents with nature.

Ultimately, by using the Literary Method of Urban Design and drawing from the narrative of *Vassil*, Ahtopol can be envisioned as a place where biophilic design and the recovery of Strandzha Nature Park work hand-in-hand. This future would embrace ecological sustainability, cultural heritage, and community engagement, transforming Ahtopol into a model of environmentally conscious development on the Black Sea coast.

Summary and Conclusions

In summary, this article applies the Literary Method of Urban Design to three Bulgarian cities—Plovdiv, Veliko Tarnovo, and Ahtopol—using literature as a guiding force for re-imagining their future urban development for the rest of this century. Each case study demonstrates how themes from selected works of Bulgarian fiction can be translated into urban design principles that respond to contemporary challenges. Despite the distinct characteristics of each city and the varying corresponding literary inspiration, certain communalities and differences arise.

A common theme across all three case studies is the emphasis on integrating nature into urban spaces. Whether through Plovdiv's eco-architectural regeneration of one of it "Seven Hills", Veliko Tarnovo's green infrastructure to adapt to increased flooding, or Ahtopol's biophilic design centered around the Strandzha Nature Park, all three cities seek to harmonize urban life with their changing natural environments. This convergence highlights the Literary Method's capacity to address environmental concerns such as sustainability, resilience,

and climate adaptation, while fostering a deeper connection between residents and their landscapes.

Another shared theme is the role of cultural and historical identity in shaping future urban designs. Plovdiv's multicultural past, Veliko Tarnovo's position as a cultural stop-over, and Ahtopol's natural heritage links all emerge as essential elements to be preserved, tolerated, and celebrated. The cities are envisioned as spaces where history and modernity and futurity coexist, reflecting the importance of dialogue between past, present and future in urban planning. However, notable differences exist in the specific future challenges each city faces and how this Method might address them to transform them in the future (as table one, below, summarizes).

Plovdiv's future is shaped by the reconciliation of religious and cultural conflicts, inspired by *Time of Parting*. Veliko Tarnovo's scenario, drawn from *The Peach Thief*, focuses on the delicate balance of creating new adaptive eco-technologies that invite rather than repel tourists, while Ahtopol's transformation, guided by *Vassil*, emphasizes community engagement in ecological restoration. These distinct thematic focuses illustrate the flexibility of the Literary Method of Urban Design to address unique urban challenges.

The strengths of this method, particularly in pedagogy, are evident throughout the article. For design, geography, and literary students, the Literary Method of Urban Design provides a multidisciplinary framework that bridges storytelling with urban analysis. It fosters critical thinking by encouraging students to draw connections between literary themes and real-world urban scenarios, enhancing their ability to approach urban challenges creatively. Moreover, this method enriches the study of geography and urban design by embedding national, cultural and environmental dimensions into forecasting the future. As a pedagogical tool, the method not only nurtures holistic thinking but also inspires innovative visions for the sustainable cities of tomorrow.

Table 1. A summary comparison of the various Bulgarian Case Study urban futures predicted by the literary method of Urban Design

Potential Urban Futures as Inspired by Reference Text	*Case Study 1: The future of Plovdiv inspired by Donchev's "Time of Parting"*	*Case Study 2: The future of Veliko Tarnovo inspired by Stanev's "The Peach Thief"*	*Case Study 3: The future of Ahtopol inspired by "Evtimova's Vassil"*
Prime Socio-emvironmental problem(s)	Ethnic divisions, natural resource conflicts	Degradation of riverine environment	Destruction of natural wetland ecosystems
Prime Change Agent(s)	Amelioration of ethnic divisions, eco-architecture	Innovative and attractive eco-technology	Community involvement in ecological restoration
Can change agent avert social disaster / eco-catastrophe?	Yes	Yes	Yes
Positive / Inspiring Forecast?	Yes	Yes	Yes

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Understanding bacterial virulence and combating multidrug resistance in tropical Southeast Asia

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ABSTRACT

This study aimed to 1) investigate the factors contributing to bacterial pathogenicity and 2) identify evidence-based strategies for prevention and control, with a focus on tropical environments like Thailand. A systematic review was conducted using peer-reviewed journals, government reports, and publicly available datasets published between 2000 and 2024. Key databases included PubMed, SpringerLink, and ScienceDirect. Studies were selected based on relevance to bacterial virulence, environmental impacts, and regional health strategies. Data were synthesized thematically around core concepts such as adhesion, invasion, toxin production, and antimicrobial resistance. Virulence in bacteria is driven by molecular factors and significantly influenced by environmental conditions such as climate change, pollution, and antibiotic misuse. Case studies from Thailand demonstrated both successful interventions (e.g., antibiotic stewardship, photodynamic therapy) and challenges in controlling bacterial spread. Regional insights emphasized the role of public health infrastructure and environmental management. Addressing bacterial pathogenicity requires a multidisciplinary approach that integrates microbiological knowledge, environmental science, and public health policy. Tailored strategies are essential for reducing bacterial threats in tropical and resource-constrained regions, and further research should bridge the gap between scientific discovery and practical implementation.

Key words: Bacterial Virulence Factors, Multidrug-Resistant Bacteria (MDR), Pathogenicity in Tropical Climates, Antibiotic Resistance Strategies, Environmental Impacts on Bacterial Infections

Introduction

Infectious diseases caused by pathogenic bacteria continue to rank among the leading causes of morbidity and mortality worldwide. According to the World Health Organization (2021), bacterial infections remain a significant public health burden, particularly in low- and middle-income countries. The growing emergence of multidrug-resistant (MDR) bacterial strains—exacerbated by inappropriate antibiotic use in both healthcare and agriculture—has intensified this global crisis, leading to infections that are increasingly difficult to treat (CDC, 2022; Koh et al., 2019).

Tropical regions, such as those in Southeast Asia, face unique challenges in bacterial infection control due to high humidity, rising temperatures, environmental pollution, urbanization, and weak public health infrastructure. These conditions not only foster the growth and transmission of pathogenic bacteria but also create hotspots for the emergence of antimicrobial resistance. Recent studies suggest that climate variability and pollution—especially from microplastics—contribute to enhanced bacterial virulence by promoting biofilm formation and resistance mechanisms (Soni et al., 2024; Zhang et al., 2023). However, the influence of these environmental factors remains underexplored in the context of molecular pathogenesis.

While a considerable body of research exists on the molecular biology of bacterial virulence—such as adhesion factors, toxins, and immune evasion mechanisms—there is a disconnect between these scientific insights and their practical application in public health strategy. Furthermore, Southeast Asia lacks region-specific reviews that integrate molecular data with local environmental and policy frameworks.

Objectives

This review addresses these gaps by synthesizing current evidence on bacterial virulence mechanisms alongside environmental and human behavioral factors, with a focus on tropical settings like Thailand. By bridging molecular microbiology and public health, the study

aimed to inform more context-sensitive prevention and control strategies in resource-limited environments.

Methods

This review synthesized peer-reviewed literature, government reports, and publicly accessible datasets to explore bacterial virulence factors and related prevention strategies. Key methods included:

1. Literature Search: Databases such as PubMed, SpringerLink, and ScienceDirect were searched for studies published between 2000 and 2024 using keywords like "bacterial virulence factors," "environmental impact on pathogenicity," "antibiotic resistance," and "infection prevention in tropical regions."

2. Criteria for Inclusion and Exclusion:

- Relevant studies with empirical data or systematic reviews were prioritized.
- Non-pathogenic studies or those with insufficient methodological details were excluded, while foundational pre-2000 studies were included selectively.

3. Data Synthesis: Extracted data were categorized into themes (e.g., adhesion, invasion, toxins, environmental impact, antibiotic resistance) and analyzed to identify trends and gaps.

4. Regional Focus: Emphasis was placed on Southeast Asian studies, especially Thailand, for context-specific insights into tropical climates and local public health strategies.

5. Validation: Sources were cross verified with credible organizations such as WHO, CDC, and national health agencies to ensure reliability.

Virulence Factors in Bacteria

The pathogenicity of bacteria is attributed to various virulence factors, each contributing to their ability to infect and persist within hosts:

1. Adhesion Factors: Adhesins, such as Type-1 pili and MSCRAMMs (Microbial Surface Component Recognizing Adhesive Matrix Molecules), facilitate bacterial attachment to host cells, initiating infection. These molecules bind to host receptors, exploiting complementary shapes to secure attachment (Sharma AK et al., 2016; Kaiser G, 2023). Adhesion is often the first step in bacterial colonization, providing a foundation for subsequent invasion and immune evasion. Some bacteria exhibit host specificity due to unique receptor-binding interactions.

2. Invasion Factors: Pathogens utilize enzymes and toxins to breach host barriers and disseminate into tissues. Enzymes such as hyaluronidase and

collagenase break down connective tissues, enabling bacteria to spread. Toxins can disrupt cellular junctions, facilitating invasion and systemic infection. (Sharma AK et al., 2016). The ability to invade host tissues allows pathogens to access nutrients and evade localized immune responses.

3. Evasion Mechanisms: Capsules, surface proteins, and antigenic variation are employed by bacteria to evade recognition and phagocytosis by the host immune system. For example, polysaccharide capsules prevent opsonization, while surface protein alterations help bacteria avoid antibody binding. (Sharma AK et al., 2016). Some bacteria, such as *Neisseria gonorrhoeae*, change their surface antigens to stay one step ahead of the host's adaptive immunity.

4. Toxins: Bacteria produce a wide array of toxins that harm host cells. Endotoxins, integral to Gram-negative bacterial membranes, trigger systemic inflammation by activating Toll-like receptor 4 (TLR4) pathways. Exotoxins, secreted by both Gram-positive and Gram-negative bacteria, target specific host cellular processes, such as inhibiting protein synthesis (e.g., diphtheria toxin) or disrupting cell membranes (e.g., hemolysins). (Leitão JH, 2008).

5. Immune Modulation: Some bacteria produce proteins, like superantigens and IgA proteases, which impair immune cell function, disrupting host defenses. (Fraser JD and Proft T, 2008) Superantigens, such as those produced by *Staphylococcus aureus*, cause excessive T-cell activation, leading to immune dysregulation and tissue damage.

6. Nutrient Acquisition: Bacteria secrete enzymes to break down host tissues, releasing nutrients essential for their survival and growth. Siderophores, for example, are molecules secreted by bacteria to scavenge iron from host proteins like transferrin and lactoferrin. This process is vital for bacterial metabolism and virulence in iron-limited environments such as the human body.

Impact of Environmental and Human Activities

Environmental changes and human behaviors play a critical role in shaping the virulence and transmission of pathogenic bacteria. In tropical regions, such as Southeast Asia, these factors exacerbate the spread of infections and contribute to the emergence of antimicrobial resistance.

1) Climate Change:

Rising temperatures and humidity levels directly influence bacterial survival, growth, and transmission dynamics. Warmer aquatic environments, for

example, enhance the proliferation of *Vibrio cholerae*, increasing the risk of cholera outbreaks. Temperature shifts also facilitate the expansion of thermophilic pathogens into previously temperate zones, altering local disease patterns and increasing public health vulnerability (Soni et al., 2024).

2) Pollution and Microplastics:

Microplastics in aquatic ecosystems serve as substrates for bacterial attachment and biofilm formation. These biofilms protect bacteria from environmental stressors, including UV radiation and chemical disinfectants, thereby increasing bacterial persistence and resistance. Moreover, industrial pollutants can create selective pressure that accelerates the development of antibiotic-resistant strains (Zhang et al., 2023; Soni et al., 2024).

3) Antibiotic Use and Misuse:

Excessive and inappropriate use of antibiotics in human medicine and animal husbandry remains a major driver of multidrug resistance. Practices such as non-prescription antibiotic use, prophylactic use in livestock, and incomplete treatment courses contribute to the selection and spread of resistant strains like Methicillin-resistant *Staphylococcus aureus* (MRSA) and carbapenem-resistant Enterobacteriaceae (CDC, 2022; Koh et al., 2019).

4) Urbanization and Habitat Disruption:

Rapid urban expansion and deforestation increase human exposure to zoonotic bacteria. Wildlife forced into closer contact with human settlements can transmit pathogens such as Leptospira or Burkholderia pseudomallei. At the same time, poor sanitation in overcrowded urban areas fosters bacterial transmission through contaminated water and surfaces (Soni et al., 2024).

4) Globalization and Human Mobility:

The increased movement of people, goods, and animals across borders facilitates the global spread of pathogenic bacteria. International travel and trade have been implicated in the introduction of antibiotic-resistant strains of *Salmonella* and *Klebsiella pneumoniae* into new regions, often outpacing public health containment strategies (WHO, 2021).

These environmental and anthropogenic factors do not act in isolation; rather, they create synergistic effects that amplify bacterial virulence and complicate infection control. Understanding these complex interactions is essential for developing targeted, context-specific

interventions to reduce the global burden of bacterial diseases.

Common Virulent Bacteria and Their Impact

The article examines various bacteria that contribute significantly to infections:

• *Staphylococcus aureus*: Known for its ability to cause a range of infections, including skin infections, toxic shock syndrome, and sepsis, this bacterium employs numerous virulence mechanisms. Toxins such as enterotoxins and toxic shock syndrome toxins, enzymes like coagulase and hyaluronidase, and its capacity to form biofilms contribute to its persistence and resistance to treatments. In hospital settings, *S. aureus* is a major concern due to its multidrug-resistant strains, such as MRSA (Methicillin-resistant *Staphylococcus aureus*) (Britannica, 2024).

• *Escherichia coli*: Although commonly found in the human gut as a harmless commensal, Pathogenic *E. coli* are classified into several types, such as Enterohemorrhagic *E. coli* (EHEC), most notably *E. coli* O157:H7. This strain causes bloody diarrhea, hemorrhagic colitis, and hemolytic uremic syndrome (HUS). The pathotype responsible for urinary tract infections is Uropathogenic *E. coli* (UPEC) cause severe diseases, including urinary tract infections, gastroenteritis, and hemolytic uremic syndrome. These strains employ Shiga toxins and adhesins to colonize and damage host tissues. Additionally, *E. coli* is a frequent cause of hospital-acquired infections, particularly in immuno-compromised individuals. (Sato A et al., 2019).

• *Pseudomonas aeruginosa*: This opportunistic pathogen primarily affects individuals with compromised immune systems, such as those with cystic fibrosis or burn wounds. Its virulence factors include biofilm formation, the production of exotoxins, and the secretion of enzymes like elastase. These mechanisms enable *P. aeruginosa* to resist antibiotics and disinfectants, making it a significant challenge in healthcare environments. (Leitão JH, 2020).

• *Streptococcus pyogenes* (Group A Streptococcus): Responsible for diseases such as strep throat, scarlet fever, and necrotizing fasciitis, *S. pyogenes* utilizes M protein, streptolysins, and hyaluronic acid capsules to evade immune responses and cause severe tissue damage. Its ability to produce superantigens contributes to systemic immune activation and toxic shock syndrome. (Patterson MJ, 1996).

• *Mycobacterium tuberculosis*: The causative agent of *tuberculosis* primarily affects the lungs but can also spread to other organs. Its cell wall contains mycolic

acids, which confer resistance to many antibiotics and allow the bacterium to survive within macrophages. This resilience makes *tuberculosis* a persistent public health challenge. (Rohde K et al., 2007).

Clostridioides difficile (formerly *Clostridium difficile*) is a major cause of antibiotic-associated diarrhea and pseudomembranous colitis. It produces toxins A and B, which damage the intestinal epithelium and trigger inflammation. These infections frequently arise after broad-spectrum antibiotic use, which disrupts the gut microbiota and permits *C. difficile* overgrowth (Bartlett, 2002).

The human immune response includes neutrophil recruitment and cytokine release to contain the infection, but in severe cases, immune dysregulation contributes to tissue damage. Effective management strategies include antibiotic therapy (e.g., vancomycin, fidaxomicin), fecal microbiota transplantation (FMT), and supportive care. Understanding both host defenses and therapeutic interventions is key to mitigating *C. difficile* pathogenicity. **Prevention and Management**

The article underscores strategies for combating bacterial pathogenicity:

1. Vaccination: Vaccines targeting specific bacterial antigens are particularly relevant in tropical climates like Thailand, where diseases such as cholera and typhoid fever are prevalent. Ensuring wide vaccine coverage in endemic regions reduces outbreaks and prevents severe cases. (CDC, 2024).

2. Improved Hygiene: In tropical climates, humidity facilitates the survival and spread of bacteria. Measures such as frequent handwashing, ensuring safe drinking water, and promoting sanitation are essential. In Thailand, initiatives to improve access to clean water and public hygiene in rural and urban areas significantly reduce diarrheal diseases. (Butt T and Von Seidlein L, 2015).

3. Environmental Management: Stagnant water and improper waste management in tropical environments can become breeding grounds for bacteria. Public health programs focused on reducing waterborne diseases in Thailand include efforts to improve drainage systems and community education. (WHO, 2024).

4. Antibiotics and Alternatives: Judicious use of antibiotics is critical to prevent the emergence of resistance. In Thailand, implementing antibiotic stewardship programs in hospitals and educating the public about the dangers of self-medication are key strategies.

Alternatives such as phage therapy and probiotics show promise in combating resistant strains. (Rappuoli R et al., 2014).

5. Community Engagement: Local education campaigns in Thailand, focusing on the prevention of bacterial infections through food safety practices and vaccination awareness, empower communities to take proactive measures against infections. (ASEAN Agrifood, 2021).

Summary of Case Studies from Thailand (Based on Critical Analysis)

1. Antibiotic Resistance:

- At Siriraj Hospital, 78.1% of patients treated for Gram-negative bacterial infections with Polymyxin B showed positive clinical outcomes. (Ngamprasertchai T et al., 2018).
- This study underscores the effectiveness of targeted antibiotic therapy for multidrug-resistant bacterial infections and highlights the need for alternative treatments to combat resistance.

2. Innovative Therapies:

- Research into Methylene Blue-mediated photodynamic therapy demonstrated its potential to treat extensively drug-resistant bacteria in nosocomial settings. (Songsantiphap C et al., 2022)
- This therapy, by activating Methylene Blue with specific light wavelengths, effectively reduces bacterial loads, providing a novel approach in antibiotic-resistant cases.

3. Environmental and Zoonotic Risks:

- Deforestation in Thailand has led to increased zoonotic bacterial infections. Wildlife reservoirs like *Leptospira* and *Burkholderia pseudomallei* have caused diseases such as leptospirosis and melioidosis due to closer human-wildlife contact. (Soni J et al., 2024)
- These findings highlight the impact of environmental disruption on bacterial pathogenicity and public health.

4. Public Health Policies:

- Thailand's National Strategic Plan for Antimicrobial Resistance exemplifies effective regional strategies to manage resistance. (Husada D et al., 2020).
- Predictive models for bacterial late-onset neonatal sepsis, achieving 95.5% diagnostic accuracy, offer scalable solutions for resource-limited settings and early interventions.

5. Hospital-Based Interventions:

- At Ramathibodi Hospital, an integrated approach combining infection control measures with environmental decontamination reduced outbreaks of carbapenem-resistant *Klebsiella pneumoniae*. (Chotiprasitsakul D et al., 2019).
- This case underscores the importance of multi-faceted strategies in managing nosocomial infections effectively.

These case studies reflect Thailand's proactive measures and challenges in combating bacterial virulence and antibiotic resistance, providing valuable insights into addressing similar issues in tropical regions globally.

Discussion

The findings of this review highlight the multifaceted nature of bacterial virulence and underscore the pressing need for integrated approaches to address pathogenicity in tropical climates. The interplay between bacterial virulence factors and environmental influences, such as climate change, pollution, and urbanization, reveals a complex network of factors exacerbating bacterial infections, particularly in resource-constrained settings like Southeast Asia. (Fraser JD and Proft T, 2008) These insights emphasize that bacterial pathogenicity cannot be effectively tackled in isolation but requires coordinated efforts across molecular research, public health, and environmental management. (Soni J et al., 2024)

Key interventions, such as antibiotic stewardship programs. (Britannica, 2024). vaccination campaigns, (Sato A et al., 2019). and public hygiene initiatives, (Patterson MJ, 1996). demonstrate significant promise in mitigating the impact of bacterial infections. However, the emergence of multidrug-resistant strains, fueled by antibiotic misuse and overuse, remains a critical challenge. (Rohde K et al., 2007) Innovative therapies, such as photodynamic antimicrobial strategies, (Bartlett JG, 2002). present a viable alternative, but their scalability and accessibility in low-resource settings need further exploration.

Region-specific factors, particularly in Thailand, add another layer of complexity. For example, the high prevalence of zoonotic infections linked to deforestation and habitat destruction underscores the need for tailored public health strategies that address both environmental and social determinants of health. (CDC, 2024). Case studies from Thailand demonstrate the effectiveness of localized interventions but also highlight gaps in widespread implementation and

monitoring. (Butt T and Von Seidlein L, 2015).

Despite these advances, significant knowledge gaps persist. For instance, the impact of microplastics as vectors for bacterial virulence in aquatic ecosystems and the long-term effects of climate change on bacterial pathogenicity warrant deeper investigation. (WHO, 2024). Additionally, there is a need to bridge the gap between molecular research and practical applications in public health policies, ensuring that scientific advancements translate into tangible outcomes for affected populations. (Rappuoli R et al., 2014).

Limitation

While this review provides a comprehensive overview of bacterial virulence factors and their interaction with environmental and human influences, several limitations should be acknowledged:

1. Data Availability: The focus on Southeast Asian studies, particularly Thailand, may limit the generalizability of findings to other regions. Comparative analyses with non-tropical settings were not extensively conducted.

2. Bias in Literature Selection: The reliance on peer-reviewed literature and government reports may have introduced selection bias, potentially overlooking unpublished or non-English studies that could provide additional insights.

3. Scope of Innovative Therapies: While promising therapies like photodynamic antimicrobial strategies were discussed, their clinical applicability and cost-effectiveness in diverse healthcare settings remain uncertain.

4. Limited Discussion on Long-Term Impacts: The long-term implications of interventions, such as vaccination and antibiotic stewardship, on bacterial evolution and resistance patterns were not thoroughly explored.

5. Environmental Factors: Although environmental impacts were discussed, detailed quantitative analyses of factors such as pollution levels or specific climate variables influencing bacterial virulence were beyond the scope of this review.

Addressing these limitations in future research could enhance the understanding of bacterial pathogenicity and inform the development of more effective, globally applicable strategies.

Conclusion

This review emphasizes the critical need for integrated approaches to combat bacterial pathogenicity, particularly in tropical and resource-limited settings. Key interventions, such as antibiotic stewardship, vaccination, and innovative

therapies like photodynamic strategies, offer promising solutions but require further research and adaptation for low-resource contexts. Addressing knowledge gaps and enhancing the integration of molecular insights with public health strategies will be essential in mitigating bacterial infections and quality care.

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Comparison of perceptions on re-purposing finished projects as teaching aids in schools

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ABSTRACT

Creative teaching aids enhance student engagement and learning outcomes by making the learning process more interactive, relatable, and memorable. These aids—ranging from visual tools like charts, diagrams, and infographics to interactive materials like models, games, diatoms, digital simulations, and multimedia content—stimulate curiosity and encourage active participation. Although a wide range of teaching aids has been utilized in educational settings, the idea of leveraging completed student projects as instructional tools remains largely underexplored. This study investigated the potential of repurposing finished projects, such as dioramas and bulletin boards, as innovative teaching aids in educational settings. The study aimed to assess undergraduate teachers and students, and 23 elementary teachers and 58 elementary students' awareness of teaching aids and to compare the perceptions regarding the challenges, benefits, and recommendations related to repurposing projects. The findings showed that there was a significant difference in awareness considering the occupation of the respondents. Also revealed in the study were the perceived challenges and benefits of the participants with regards to diorama and bulletin board.

Keywords: Teaching aids, Dioramas, Bulletin boards, Learning aids, Curriculum integration.

Introduction

In recent years, educators have increasingly emphasized the value of hands-on projects, such as dioramas and bulletin boards, in enhancing student learning and engagement. These creative works serve as a means of demonstrating understanding and applying knowledge, often with significant time and effort invested by students. However, once graded, these projects are frequently discarded, leading to wasted resources and missed opportunities for further

educational use. This raises critical questions about the potential of repurposing such projects as teaching aids, particularly in schools that suffer from a lack of instructional materials. The exploration of this issue is especially relevant in the context of educational institutions like the Asia-Pacific International University (AIU) and the Adventist International Mission School (AIMS), where student-made projects are often disposed after evaluation.

The core problem addressed in this research is how repurposing finished projects can alleviate the shortage of teaching aids in schools. This issue stems from two primary concerns: first, the extensive wastage of student-created resources, and second, the ongoing deficiency of teaching materials, which affect the quality of education in resource-constrained schools (Shabiralyani, Hasan, Hamad, & Iqbal, 2015). By investigating the awareness, challenges, and benefits of using dioramas and bulletin boards as teaching aids, this study aims to offer practical recommendations for maximizing the utility of these often-neglected materials. Specifically, the research will examine participants' familiarity with dioramas and bulletin boards, assess whether awareness varies by factors such as gender, age, occupation, and country of origin, and explore the perceived challenges and advantages of repurposing these projects for instructional purposes.

Literature review

While many teaching aids have been explored, there is little attention given to the potential of using finished projects as teaching aids in schools.

Teaching aids are vital tools that enhance student learning by simplifying complex concepts and engaging multiple senses (Ordu, 2021). They can range from simple visuals like posters to interactive resources such as digital media and physical models (Višnić, Bibić, Vučković, Ivkov-Džigurski, & Kotnik, 2017). The primary aim of these aids is to support lesson objectives and accommodate various learning styles, ultimately improving comprehension, retention, and engagement in a dynamic learning environment. Project-Based Learning (PBL) further benefits from teaching aids, as they provide tangible ways to explore concepts (Kokotsaki, Menzies, & Wiggins, 2016). Teaching aids like dioramas or bulletin boards not only showcase students' creative outputs but also serve as practical tools for instruction, making learning more meaningful as students apply their skills and knowledge in real-world contexts.

Dioramas, which are three-dimensional models representing scenes or concepts, have long been utilized as effective educational tools, especially for visualizing abstract or complex ideas (Prasetya & Maisaroh, 2023). Their immersive nature helps bridge the gap between theoretical

concepts and practical understanding, making learning more interactive and memorable (Cools, Conradie, Ciocci, & Saldien, 2018). In the context of PBL, dioramas help students demonstrate their comprehension of specific subjects, whether in history, geography, or science. As students craft dioramas, they develop critical thinking and creative problem-solving skills, reinforcing what they have learned.

Bulletin boards are another versatile teaching aid, functioning as dynamic spaces where teachers and students can display information, student work, or important announcements. Bulletin boards promote collaboration and serve as a focal point for communication and interaction within the classroom (Hardy, 1923). Different types of bulletin boards—announcement, educational, thematic, and interactive—offer unique benefits, ranging from disseminating information to engaging students in ongoing class discussions (Fuvesi, 2009). Interactive boards, in particular, can foster deeper student engagement by prompting participation through polls, questions, or creative contributions.

One of the most pressing challenges in education is the lack of adequate teaching resources. Studies highlight how the shortage of teaching aids in underfunded schools can negatively affect both teaching quality and student outcomes (Maffea, 2020). The lack of interactive tools and materials often leads to diminished learning experiences, especially for disadvantaged student groups, exacerbating existing educational disparities. Teachers in resource-limited environments may face burnout as they struggle to provide engaging lessons without the necessary materials.

Despite these challenges, there is untapped potential in repurposing finished student projects, such as dioramas and bulletin boards, as teaching aids. By doing so, schools can not only mitigate resource shortages but also promote sustainability by reducing waste. This strategy leverages students' creative efforts, allowing their work to serve as an instructional resource for future learners, thereby enriching the educational environment without additional costs (Maulana, Kolbi, Heriyadi, & Pahmi, 2023). Encouraging university students to donate their projects to resource-poor schools is a practical solution, aligning with Maffea's (2020) recommendation to involve the community in overcoming resource constraints.

Several related studies reinforce the importance of creative teaching aids in enhancing student engagement and learning outcomes. For instance, Maulana et al. (2023) demonstrate how teaching aids improve students' understanding of difficult subjects like mathematics. Similarly, Kamaruddin and Sulaiman (2017) discuss how interface design in teaching aids, particularly in higher

education, can influence student engagement and learning efficacy. Both studies underscore the importance of well-designed, interactive tools in education, validating the premise that repurposed projects can serve as effective teaching aids.

Research objectives

This study aims to assess the level of awareness among teachers and students regarding the use of finished student projects as teaching aids, and to compare the perceptions of the benefits, challenges, and recommendations related to repurposing the materials in classroom settings. It also seeks to explore how respondents' roles influence their view on the effectiveness of reusing the projects for educational purposes.

Significance of the study

By exploring this topic, the research will enhance understanding of how to mitigate wasted student effort and address the shortage of educational resources in schools. By highlighting the benefits and barriers of repurposing finished projects, this research seeks to inform educators, administrators, and policymakers about effective strategies for optimizing resource use in classrooms.

Research methods

This study employs a quantitative research design to gather and analyze numerical data about the perspective of stakeholders on the repurposing of finished projects (dioramas and bulletin boards) as teaching aids in educational settings. A structured survey instrument will be used to collect data from participants, allowing for systematic comparison and analysis of responses.

The population of this study includes Asia-Pacific International University (AIU) education students, AIU Education teachers, AIU Education department administrators, and Adventist International Mission School (AIMS) teachers. Located in Muak Lek, Thailand, AIU is a private institution approximately 108 kilometers (about 67.11 mi) northeast of Bangkok. As of the second semester of 2024, AIU boasts a diverse student body of approximately 100 sophomores to senior bachelor education students, with a dedicated faculty of 13 education teachers and administrators. Aside from AIU, the study also involves Adventist International Mission School (AIMS), an affiliated institution. The AIMS faculty includes approximately 34 teachers. The study will be conducted within the premises of Asia-Pacific International University, focusing on stakeholders within the university community and affiliated schools to gather insights and perspectives on the research topic.

Stratified sampling technique is employed to ensure representation from different stakeholder groups within the population. Stratification is based on participant categories such as AIU education students, AIU education teachers, AIU

administrators, and AIMS teachers. Approximately 60% of the total population was targeted for participation, and a total of 89 individuals responded to the survey. Random sampling methods are then used within each group to select participants, ensuring that each subgroup is adequately represented in the sample (Parsons, 2014). Data were collected through surveys administered on-site to participants. Participants will be provided with clear instructions for completing the survey, ensuring confidentiality and anonymity of responses. The data collected will be processed using jamovi and Microsoft Excel.

The study reveals positive attitudes towards finished dioramas and bulletin boards as educational tools, highlighting their potential to enhance learning experiences. However, challenges such as resource limitations and issues with engagement and relevance were found, emphasizing the need for careful integration into the curriculum. Demographic factors like age and occupation influence awareness levels, with educators showing greater awareness than students. Comparing teacher and student perspectives highlighted common concerns about resources and engagement, showing the importance of tailored educational approaches. Therefore, integrating interactive tools like finished dioramas and bulletin boards holds promise for enhancing student engagement, understanding, and creativity in the classroom.

Results and discussion

Table 1 *Awareness of Diorama*

Diorama	Mean	SD
I have made a diorama.	3.99	1.309
I am familiar with the concept of using diorama as teaching aids in schools.	3.74	1.189
I have a clear understanding of how diorama can enhance the learning experience in the classroom.	3.92	1.096
Diorama explains complex educational concepts in a visually engaging manner.	4.03	0.903
The purpose of using diorama often aligns with the learning objectives of the curriculum.	3.98	0.982
Average	**3.932**	**1.0958**

The findings from respondents' ratings highlight a generally positive attitude toward dioramas as teaching aids. With a mean score of 3.99, respondents demonstrated high practical experience and involvement in creating dioramas. They recognized dioramas' ability to enhance learning (mean rating of 3.92) and communicate complex concepts effectively (mean rating of 4.03), while also aligning with curriculum objectives (mean rating of 3.98). Despite familiarity with using dioramas in schools (mean rating of 3.74), the data confirms their effectiveness as engaging instructional tools (McGregor, Deb, & Gadd, 2019).

Table 2 *Awareness of Bulletin Boards*

Bulletin Board	Mean	SD
I have made a bulletin board.	3.98	1.338
I am familiar with the concept of using bulletin boards as educational tools.	3.91	1.141
I understand how bulletin boards can be effectively utilized in educational settings.	4.11	0.877
Bulletin boards are effective in visually communicating important information to students.	4.23	0.854
The use of bulletin boards significantly enhances the learning environment in educational institutions.	4.18	0.838
Average	4.082	1.0096

The respondents' ratings indicate a high level of engagement and positive perception of bulletin boards as educational tools. They reported strong practical involvement, with a mean rating of 3.98 for having created bulletin boards themselves, and a solid familiarity with their use in educational contexts (mean rating: 3.91). Respondents also demonstrated a deep understanding of bulletin boards' effectiveness (mean rating: 4.11), recognizing their ability to visually communicate important information (mean rating: 4.23) and enhance the learning environment (mean rating: 4.18). These findings highlight respondents' belief in bulletin boards as valuable instructional resources. (Dos Santos & Wright, 2006). (See Table 2)

Table 3 *Awareness of Diorama by Gender*

Gender	Number	Mean	SD	SE
Male	60	3.92	0.962	0.124
Female	28	3.95	0.784	0.148
	F	df1	df2	p
Welch's	0.019	1	63.8	0.891
Fisher's	0.0164	1	86	0.898

The study's findings showed that there was no difference in how aware male and female participants were about dioramas. It shows that both genders showed similar levels of awareness (Males: M = 3.92, SD = 0.962; Females: M = 3.95, SD = 0.784). This shows that regardless of gender, individuals have similar levels of understanding and familiarity with dioramas as teaching tools. Statistical tests, including Welch's and Fisher's independent samples t-tests, yielded non-significant p-values ($p > 0.05$), further supporting the conclusion that gender did not influence the participants' awareness of dioramas. (See Table 3)

Table 4 *Awareness of Diorama by Age*

Age	Number	Mean	SD	SE
18-24	42	3.7	0.909	0.1402
25-34	28	3.84	0.893	0.1687
35-44	3	4.53	0.643	0.3712
45-54	9	4.47	0.656	0.2186
55-64	6	4.87	0.242	0.0989
	F	df1	df2	p
Welch's	12.5	4	12	< .001
Fisher's	3.92	4	83	0.006

The study results indicate a significant difference in awareness of dioramas across age groups. Participants aged 18–24 scored an average of 3.7, while those aged 25–34 scored 3.84. Older participants demonstrated higher awareness, with scores of 4.53 for the 35–44 age group, 4.47 for the 45–54 age group, and 4.87 for those aged 55–64. Welch's and Fisher's tests confirmed significant differences in awareness ratings among age groups ($p < .001$ and $p = 0.006$, respectively). These findings suggest that awareness of dioramas increases with age, with older participants exhibiting greater awareness than their younger counterparts. (See Table 4)

Table 5 *Awareness of Diorama by Country of Origin*

Country	N	Mean	SD	SE
Thailand	9	3.69	0.831	0.277
Myanmar	36	3.74	0.86	0.143
Malaysia	6	4.13	0.653	0.267
Philippines	14	4.69	0.536	0.143
Cambodia	4	3	1.071	0.535
India	3	4.13	0.808	0.467
China	12	3.77	1.102	0.318
Others	4	4.55	0.342	0.171
	F	df1	df2	p
Welch's	4.08	7	14.7	0.011
Fisher's	3.18	7	80	0.005

The study's findings indicated; a significant difference in diorama awareness among participants from different countries. Filipino participants had the highest mean awareness score of 4.69, followed by Malaysian participants at 4.13, while Cambodian participants had the lowest score of 3.00. Statistical tests, including Welch's and Fisher's independent samples t-tests, confirmed substantial differences in awareness scores among countries ($p = 0.011$ and $p = 0.005$, respectively). These results suggest that awareness of dioramas varies significantly based on participants' countries of origin, with some exhibiting higher levels of awareness than others. (See Table 5)

Table 6 *Awareness of Diorama by Occupation*

Occupation	N	Mean	SD	SE
AIU Education Teachers	*6*	*4.87*	*0.242*	*0.0989*
AIMS Teachers	*23*	*4.45*	*0.616*	*0.1284*
AIU Education Students	*59*	*3.63*	*0.89*	*0.1159*
	F	df1	df2	p
Welch's	32.2	2	27.2	< .001
Fisher's	13	2	85	< .001

The study's results indicate a significant difference in diorama awareness across different occupations. Teachers from AIU Education and AIMS had the highest mean awareness scores, with AIU Education Teachers scoring 4.87 (SD = 0.242) and

AIMS Teachers scoring 4.45 (SD = 0.616). In contrast, AIU Education Students had a lower mean awareness score of 3.63 (SD = 0.89). Statistical tests, including Welch's and Fisher's independent samples t-tests, confirmed that these differences were significant ($p < .001$). This suggests that educators have a higher awareness of dioramas compared to students. (See Table 6)

Table 7 *Awareness of Bulletin Boards by Gender*

Gender	N	Mean	SD	SE
Male	60	4.11	0.812	0.105
Female	27	4.01	0.899	0.173
	F	df1	df2	p
Welch's	0.237	1	45.9	0.629
Fisher's	256	1	85	0.614

The study revealed that there was no contrast in the awareness of bulletin boards between male and female participants. Both genders shown comparable levels of awareness, with males averaging a score of 4.11 and females slightly lower at 4.01. Welch's and Fisher's independent samples t-tests, yielded non-significant p-values ($p > 0.05$), showing that gender did not influence participants' awareness of bulletin boards (see Table 7).

Table 8 *Awareness of Bulletin Boards by Age*

Age	N	Mean	SD	SE
18-24	42	3.84	0.866	0.134
25-34	27	4.13	0.832	0.16
35-44	3	4.47	0.503	0.291
45-54	9	4.49	0.617	0.206
55-64	6	4.77	0.32	0.131
	F	df1	df2	p
Welch's	5.77	4	12	0.008
Fisher's	2.84	4	82	0.029

The data indicated that awareness of bulletin boards varied across different age groups. The average awareness scores were as follows: 18–24 years: 3.84, 25–34 years: 4.13, 35–44 years: 4.47, 45–54 years: 4.49, and 55–64 years: 4.77. Welch's and Fisher's ANOVA tests revealed statistically significant

differences in awareness scores among age groups ($p < 0.05$). This suggests that age significantly influences participants' awareness of bulletin boards, with notable variations across demographics. (See Table 8)

Table 9 *Awareness of Bulletin Boards by Country of Origin*

Country	N	Mean	SD	SE
Thailand	9	3.98	0.484	0.161
Myanmar	35	3.91	0.868	0.147
Malaysia	6	3.93	0.927	0.378
Philippines	14	4.71	0.398	0.106
Cambodia	4	3.2	1.166	0.583
India	3	4.6	0.693	0.4
China	12	3.98	0.9	0.26
Others	4	4.6	0.365	0.183
	F	df1	df2	p
Welch's	3.93	7	14.4	0.013
Fisher's	2.79	7	79	0.012

Data analysis reveals considerable variation in participants' awareness of bulletin boards based on their country of origin. Filipino participants had the highest awareness level, with an average score of 4.71 (SD = 0.398), followed by participants from India at 4.60 (SD = 0.693). In contrast, individuals from Cambodia exhibited the lowest awareness, averaging 3.20 (SD = 1.166). Statistical tests, including Welch's and Fisher's ANOVA, confirmed significant differences in awareness scores among nations ($p < 0.05$). This indicates that country of origin influences awareness, with notable disparities across different countries. (See Table 9)

Table 10 *Awareness of Bulletin Boards by Occupation*

Occupation	N	Mean	SD	SE
AIU education teachers	6	4.77	0.367	0.15
AIMS teachers	23	4.51	0.555	0.116
AIU Education Students	58	3.84	0.861	0.113

	F	df1	df2	p
Welch's 14.3	14.3	2	18.5	< .001
Fisher's 8.83	8.83	2	84	< .001

The survey revealed that awareness of bulletin boards varies by occupation. AIU Education instructors had the highest average awareness score of 4.77, followed by AIMS teachers at 4.51, while AIU Education Students scored lower at 3.84. Statistical tests, including Welch's and Fisher's t-tests, confirmed significant differences in awareness scores across occupational groups ($p < .001$). This indicates that occupation influences awareness, with educators being more knowledgeable than students. (See Table 10)

Educators and students share similarities and differences in their views on the challenges of using completed dioramas in classrooms. Both groups expressed concerns about limited resources, such as time and materials, along with issues of student participation and curriculum relevance. They recognized the importance of addressing creativity and maintenance of dioramas. Teachers highlighted the complexity of dioramas for young learners and the potential for repetitive educational value, while students focused on academic challenges like topic selection and information adequacy. Additionally, students raised concerns about coordination and logistics, while teachers were more concerned about finding schools willing to adopt diorama-based learning. These perspectives emphasize the need for careful planning and deliberation to tackle the obstacles associated with using dioramas in education.

Teachers and students at AIU share concerns about the use of bulletin boards in education. Teachers emphasize that the content should align with their lessons and be accurate, while also mentioning challenges with transporting boards and engaging interest. Students echo these concerns, questioning the accuracy of the information and the difficulty of moving boards without damage. Both groups discuss practical issues like design, relevance, durability, and maintenance responsibilities, agreeing that these challenges must be addressed for bulletin boards to be effective educational tools. Regarding reusing completed projects, students view dioramas positively, believing they enhance engagement, understanding, and creativity. They suggest displaying projects in classrooms, libraries, or at other schools, but worry about resource limitations and ensuring efficiency and relevance. Teachers also see value in imaginative projects, recommending sharing them with other schools, using them during internships, or organizing fairs for feedback. Both groups agree that reusing projects makes learning more enjoyable and promotes greater involvement in school activities.

Discussion and conclusion

This study aimed to assess the awareness of dioramas and bulletin boards as

educational tools among students and teachers from Asia-Pacific International University (AIU) and Adventist International Mission School (AIMS). The hypotheses explored whether demographic factors such as gender, age, country of origin, and occupation influence awareness levels.

The data showed less significant gender differences in awareness of dioramas ($p=0.891$) or bulletin boards ($p=0.629$). This aligns with social cognitive theory (Bandura, 1986), which says that equal exposure to learning environments fosters similar knowledge and attitudes across genders.

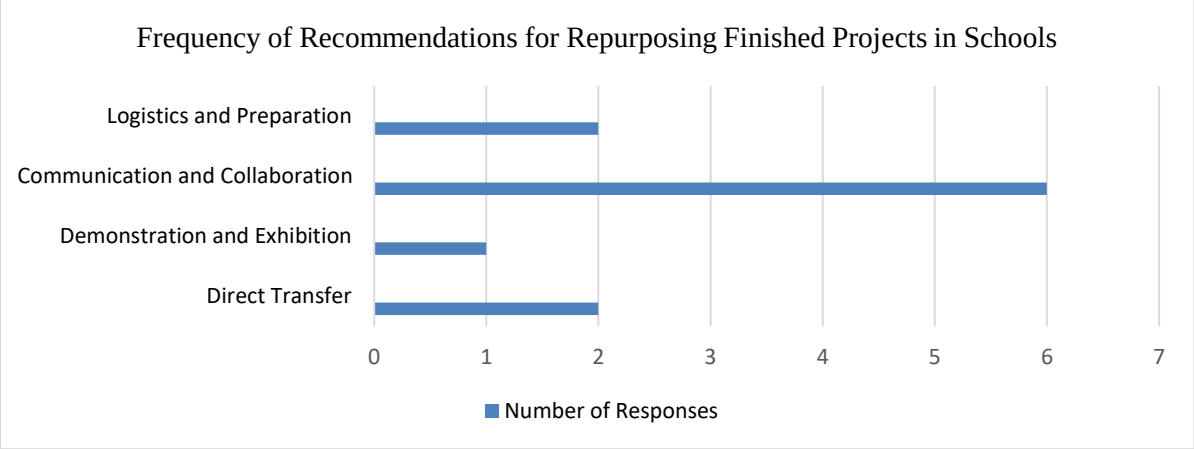
Age, however, played a notable role. Older participants showed higher awareness levels, which aligns with Knowles' Adult Learning Theory (1984), suggesting that experience over time deepens familiarity with educational tools.

Cultural background also influenced awareness. Participants from the Philippines and India score higher, a pattern explained by Hofstede's cultural dimensions theory (1980), which highlights how cultural values shape engagement with collaborative and visual learning methods like dioramas and bulletin boards.

Occupation was another important factor, with educators demonstrating significantly greater awareness than students. This support constructivist learning theory (Piaget, 1952), which emphasize the teacher's role as a guide who facilitates learning through instructional aids.

Both groups acknowledged challenges, particularly limited resources and difficulties aligning these tools with the curriculum. These concerns mirror findings by McGregor, Deb, and Gadd (2019), who discuss practical barriers in using dioramas effectively. The appreciation for creativity and the reuse of projects reflects Kolb's experiential learning theory (1984), which stresses the importance of active engagement for deeper learning.

This study met its objective by demonstrating that awareness of dioramas and bulletin boards as educational tools is influenced by age, country of origin, and occupation, but not by gender. These findings support educational theories such as adult learning, constructivism, and cultural learning frameworks. It shows the importance of experience, cultural background, and professional role in shaping awareness.



Research implication

The recommendations for repurposing finished projects in schools emphasize several key strategies, with the most recommended being communication and collaboration with different schools. Effective communication between teachers, students, and various schools ensures that finished projects, such as dioramas and bulletin boards, are used as valuable teaching aids. Collaborating with schools and organizations helps tailor these projects to meet specific educational needs. Direct transfer is another approach, where students or teachers can deliver the projects to schools, either transporting smaller items by car or arranging collection by school personnel. Demonstration and exhibition of projects are also encouraged, allowing students to visually present their work and further engage audiences. Logistics and preparation are crucial, involving proper documentation, packaging, and labeling to ensure the safe transport of projects. This requires careful planning and coordination to facilitate smooth delivery and effective use in schools. These strategies highlight the importance of collaboration and preparation to maximize the educational value of repurposed projects.

Limitation and recommendation for further research

The limitation of this research is its focus on a specific educational community, the Asia-Pacific International University (AIU) and Adventist International Mission School (AIMS), which may restrict the findings to broader educational contexts.

Expanding the sample size and including participants from diverse educational institutions and regions would enhance the generalizability of the findings.

Researchers could also explore the impact of specific design elements of dioramas and bulletin boards on student engagement and learning outcomes.

Future research should focus on longitudinal studies to track changes in awareness and perceptions of dioramas and bulletin boards among educators and students over time.

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Multivariate GARCH analysis of return spillovers between Fed Rate changes, decentralized finance (DeFi) assets, and stock indices

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ABSTRACT

This study examined the dynamic interrelationships and volatility spillovers among decentralized finance (DeFi) assets, traditional stock indices, commodities, and macroeconomic policy through the lens of multivariate GARCH models. Using daily time series data spanning from January 10, 2023, to December 31, 2024, the study applied both DCC-GARCH(1,1) and BEKK-GARCH models to a diversified 15-asset portfolio comprising stablecoins (USDC, USDT, BUSD, TUSD, DAI, GUSD), cryptocurrencies (Bitcoin, Ethereum), commodities (gold, crude oil), U.S. equity indices (Dow Jones, S\&P 500, Nasdaq, NYSE), and the Federal Funds Rate. The findings revealed significant return and volatility spillovers, particularly from Federal Reserve interest rate changes to both digital and traditional markets. Bitcoin and Ethereum showed strong co-movements with major stock indices, highlighting their increased integration into global financial systems. In contrast, stablecoins exhibited lower volatility and weaker interlinkages, confirming their role as volatility dampeners. Gold continued to function as a safe-haven asset, while oil's influence was episodic and context-dependent. The time-varying and asymmetric nature of these relationships, especially during macroeconomic stress, underscores the need for adaptive investment strategies and greater regulatory coordination. This paper contributes to the literature by offering a comprehensive multivariate volatility modeling framework that bridges digital finance and macroeconomic dynamics.

Keywords: Decentralized Finance (DeFi), Cryptocurrencies, Stablecoins, Stock Indices, Volatility Spillover

Introduction

The intricate relationship between macroeconomic policy particularly U.S. Federal Reserve interest rate adjustments and the behavior of global financial assets has emerged as a pivotal area of inquiry in contemporary financial economics. As financial markets become increasingly integrated, the emergence of decentralized finance (DeFi) assets, including cryptocurrencies and stablecoins, has added new dimensions to the analysis of volatility transmission and return dynamics. Concurrently, traditional asset classes such as commodities and equity indices continue to play a central role in shaping investor portfolios and market expectations.

Recent global disruptions, most notably the COVID-19 pandemic, have amplified the interconnectedness of financial markets, leading to shifts in investor sentiment, heightened systemic risk, and non-linear co-movements across asset classes (Liu & Serletis, 2019; Lahmiri & Bekiros, 2020; Fernandes et al., 2022). In this evolving landscape, stablecoins like USDC and USDT have gained prominence as potential volatility stabilizers, often viewed as safe-haven assets amid macroeconomic uncertainty and cryptocurrency market turbulence (Al-Afeef et al., 2024; Napari et al., 2025).

Empirical research increasingly points to dynamic, time-varying, and asymmetric relationships between digital assets and traditional financial instruments, with evidence of bidirectional volatility spillovers involving stock indices (e.g., S&P 500), commodities (gold and oil), and cryptocurrencies such as Bitcoin and Ethereum (Kim et al., 2020; Ahmed et al., 2023; Gokmenoglu & Fazlollahi, 2016). However, many of these studies rely on univariate or bivariate frameworks, limiting their ability to capture the multidimensional interdependencies and regime-switching behaviors inherent in financial markets today.

This study addresses this gap by employing a robust multivariate volatility modeling approach specifically the Dynamic Conditional Correlation GARCH (DCC-GARCH) (1,1) model alongside the BEKK-GARCH specification to examine the

volatility clustering, return spillovers, and dynamic correlations across a 15-asset portfolio. The portfolio includes major stablecoins, leading cryptocurrencies, key U.S. stock indices, commodities (gold and oil), and the Federal Funds Rate as a macroeconomic proxy. By analyzing time series data from January 10, 2023, to December 31, 2024, the study provides new insights into the evolving nature of cross-asset linkages in a post-pandemic, rate-sensitive financial environment.

Research objectives

1. To investigate the volatility clustering behavior in a cross-asset portfolio including stablecoins (USDC, USDT, BUSD, TUSD, DAI, GUSD), cryptocurrencies (Bitcoin and Ethereum), commodities (gold and oil), and major U.S. stock indices (Dow Jones, S&P500, Nasdaq, NYSE), as well as the Federal Funds Rate.

2. To analyze the dynamic conditional correlations among the assets using a DCC-GARCH framework, especially under macroeconomic stress and interest rate shifts.

3. To examine volatility spillover effects between the Federal Reserve's policy actions and the return dynamics of digital and traditional financial assets.

Literature review

The intersection of cryptocurrency markets, traditional financial assets, and macroeconomic policy has attracted increasing scholarly attention in recent years. A number of studies have examined the dynamic interactions, spillovers, and hedging relationships among these assets, especially during periods of heightened uncertainty.

Thaker and Mand (2021) conducted a comprehensive investigation of the relationship between Bitcoin and stock markets using a suite of econometric tools including the VECM, Granger Causality Test, M-GARCH-DCC, and Continuous Wavelet Transform. Their findings confirmed the existence of both short- and long-run relationships, along with time-varying co-movements that reflect market integration and lead-lag dynamics. Similarly, Ahmed et al. (2023) emphasized mutual coupling between stock markets and major cryptocurrencies, identifying bidirectional causality with stronger spillovers from equities to digital assets, contradicting the notion of cryptocurrencies as consistent hedging instruments.

Kim et al. (2020) extended this understanding by applying copula-based models, such as GC-DCC and GCNA-DCC,

which outperformed traditional models in capturing non-linear dependencies and volatility clustering between Bitcoin, gold, and the S&P 500. Their work confirmed the increasing positive correlation during the COVID-19 period, a pattern also corroborated by several wavelet and rolling-window studies in ASEAN contexts (Nguyen et al., 2022; Caferra & Vidal-Tomás, 2021).

A growing body of research also explores the unique role of stablecoins. Al-Afeef et al. (2024) demonstrated that trust, regulation, and perceived usefulness significantly drive stablecoin adoption, positioning these assets as effective volatility mitigation tools during market turbulence. This view is supported by Napari et al. (2025), who showed that stablecoins absorb return shocks from EM currencies, further endorsing their safe-haven characteristics.

In the context of commodities, studies by Gokmenoglu and Fazlollahi (2016) and Sujit and Kumar (2011) revealed long-term cointegration between gold, oil, and equity markets, with gold consistently acting as a substitute asset in periods of uncertainty. However, Iscan (2015) found no cointegration in the Turkish market, indicating that such relationships are not universally applicable.

Volatility has remained a persistent feature in cryptocurrency markets. Liu and Serletis (2019) emphasized Bitcoin's heightened volatility and its evolving role as a diversification tool in ASEAN markets. Likewise, Sui et al. (2022) and Lahmiri & Bekiros (2020) noted that post-COVID-19 dynamics have increased the complexity and irregularity in crypto-equity relationships, requiring more flexible modeling frameworks.

Several recent studies adopt wavelet and multivariate GARCH approaches to capture time-varying spillovers. For instance, Rijanto (2023) and Abakah et al. (2024) demonstrated that Bitcoin exhibits both safe-haven and contagion properties depending on macroeconomic conditions and investor sentiment. Moreover, the evolution of the cryptocurrency-stock relationship is increasingly attributed to investor attention, market liquidity, and regulatory stances (Ang & Chow, 2023; Soepriyanto et al., 2023).

Despite these advances, the literature lacks a comprehensive multivariate GARCH-based analysis incorporating both macroeconomic shocks such as Federal Reserve rate changes and a full asset

portfolio consisting of stablecoins, major cryptocurrencies, stock indices, and commodities. This paper addresses this gap by applying a multivariate GARCH framework to assess return and volatility spillovers across these diverse asset classes, contributing to the understanding of financial contagion and market interdependencies in a post-pandemic, rate-sensitive global environment.

Research hypothesis

The increasing integration of global financial markets, the rise of cryptocurrencies, and the heightened sensitivity of assets to monetary policy actions have prompted extensive research into the interconnectedness of asset classes. This study aims to explore the return spillover effects and volatility transmission among major digital assets, traditional financial markets, and macroeconomic indicators—especially in response to U.S. Federal Reserve interest rate changes.

Spillovers between Fed Rate changes and asset markets

Monetary policy announcements particularly changes in the Federal Funds Rate are known to influence investor sentiment, risk appetite, and capital flows. Previous studies have shown that interest rate hikes often lead to equity market corrections, while unconventional monetary policies may bolster riskier assets such as cryptocurrencies. Given the increased relevance of Fed decisions in shaping global financial volatility, the following hypothesis is proposed:

H1: Changes in the Federal Funds Rate generate significant return spillovers to both cryptocurrency markets and traditional stock indices.

Linkage between cryptocurrencies and stock markets

The empirical literature is mixed on whether cryptocurrencies act as hedging tools or behave similarly to equities. While some studies suggest that Bitcoin and Ethereum are decoupled from traditional markets, others observe stronger co-movements during crises. Hence, the following hypotheses are developed to test both volatility and return linkages:

H2a: There exists a significant return spillover effect from the U.S. stock market to major cryptocurrencies (Bitcoin and Ethereum).

H2b: There exists a significant volatility spillover from the U.S. stock market to major cryptocurrencies.

H2c: The return and volatility spillovers between stock indices and cryptocurrencies are time-varying and

intensify during periods of macroeconomic uncertainty.

Role of stablecoins in market stabilization

Stablecoins are designed to reduce volatility by pegging their value to fiat currencies or commodities. Recent research positions stablecoins as a "safe haven" during market turbulence, offering investors a less volatile store of value. Based on this role, the study posits:

H3a: Stablecoins exhibit significantly lower return volatility than major cryptocurrencies.

H3b: Stablecoins demonstrate weaker return and volatility spillovers with stock indices compared to Bitcoin and Ethereum.

Interactions among commodities, cryptocurrencies, and equities

Gold and oil remain critical indicators of global market sentiment and economic performance. Their relationship with digital assets remains complex, especially during inflationary pressures or geopolitical risks. Thus, we hypothesize:

H4a: Gold serves as a volatility absorber, reducing the impact of return shocks from cryptocurrencies.

H4b: Oil prices exhibit bidirectional volatility spillovers with major cryptocurrencies, reflecting energy cost sensitivity in crypto mining and broader economic activity.

Time-varying dynamics and asymmetric spillovers

Financial markets often exhibit regime-switching behavior and asymmetric responses to positive and negative shocks. Accordingly:

H5: The intensity and direction of return and volatility spillovers among the Fed, cryptocurrencies, commodities, and equity indices are time-varying and exhibit asymmetries during high-volatility periods.

Research methodology

To investigate the return and volatility dynamics among cryptocurrencies, stablecoins, traditional stock indices, commodities, and macroeconomic indicators, this study employs a Univariate GARCH(1,1) model for each asset in a 15-asset portfolio. The assets are categorized as follows:

- Stablecoins: USDC, USDT, BUSD, TUSD, DAI, GUSD
- Cryptocurrencies: Bitcoin (BTC), Ethereum (ETH)
- Commodities: Gold, Crude Oil
- Stock Indices: Dow Jones Industrial Average, S\&P 500, Nasdaq, NYSE Composite

- Macroeconomic Variable: Change in the Federal Funds Rate (FED)

The dataset comprises daily closing prices and rates for selected financial assets, covering the period from 10 January 2023 to 31 December 2024, resulting in 423 observations per asset. Data collection was carried out using Python in Google Colab, leveraging the yfinance library to extract price data from Yahoo Finance, a widely used and reputable financial data source. This method ensures consistency and comparability across all assets. The Federal Funds Rate data were obtained directly from official Federal Reserve releases and processed to reflect daily changes in the target rate.

Return Calculation

$$R_t = \ln(P_t) - \ln(P_{t-1})$$

where R_t denotes the return at time t, and P_t and P_{t-1} represent the closing prices on days t and t−1, respectively.

Mean Equation (for each asset)

$$r^{i,t} = \mu i + \varepsilon^{i,t}, \quad with \quad E[\varepsilon^{i,t}] = 0, Var(\varepsilon^{i,t}) = h^{i,t}$$

Where:

μi is the unconditional mean return of asset i

$\varepsilon^{i,t}$ is the shock or innovation to returns

Variance Equation (GARCH(1,1) Specification)

$$h^{i,t} = \omega i + \alpha i \varepsilon^{i,t-1} + \beta i h^{i,t-1}$$

Where:

$h^{i,t}$ is the conditional variance of asset i at time *t.*

ωi is a constant (usually small).

αi capture the short-term impact of shocks (ARCH effect).

βi capture the long-term persistence of volatility (GARCH effect).

Modeling All 15 Assets Simultaneously, the set of equations more compactly as:

$$r^{i,t} = \mu i + \varepsilon^{i,t},$$

$$\varepsilon^{i,t} \sim N(0, h^{i,t}),$$

$$h^{i,t} = \omega i + \alpha i \varepsilon^{i,t-1} + \beta i h^{i,t-1},$$

for USDC, USDT, BUSD, TUSD, DAI, GUSD, Bitcoin, Ethereum, GOLD, OIL, Dow Jones, S&P500, Nasdaq, NYSE, FED.

Following the univariate GARCH estimation, a Multivariate GARCH framework such as the Dynamic Conditional Correlation GARCH (DCC-GARCH) model—will be employed to analyze conditional correlations and volatility spillovers among the assets. This approach is essential for examining contagion and co-movement effects, particularly in response to macroeconomic shocks such as changes in the Federal Funds Rate. The foundational work by Engle (1982), who introduced the ARCH model, and Bollerslev (1986), who extended it to the GARCH model, provides the theoretical basis for these models.

Empirical results

Table 1 provides the descriptive statistics of daily return series for the 15 financial and macroeconomic assets in the sample. The dataset spans 423 observations for each asset. The descriptive results reveal that Bitcoin and Ethereum exhibit the highest levels of average return (0.3149% and 0.1445%, respectively), accompanied by significant standard deviations (2.8960 and 3.1736), confirming their high volatility nature. In contrast, stablecoins such as USDC and USDT exhibit negligible average returns with markedly lower standard deviations, reflecting their intended price stability.

The Federal Funds Rate (FED) return series shows a near-zero mean and moderately high dispersion, suggesting intermittent but substantial changes in policy stances. Commodities (GOLD, OIL) and indices (S&P500, Nasdaq) present moderate average returns and volatilities, falling between cryptocurrencies and stablecoins. The wide range between minimum and maximum returns in assets such as TUSD and Ethereum underscores the presence of large shocks, warranting volatility modeling using GARCH-type frameworks.

Table 1 Descriptive Statistics

ASSETS	n	Mean	Std. Dev.	Min	25%	75%	Max
USDC	423	0.002166	0.039108	-0.186532	-0.00875	0.01045	0.6933
USDT	423	0.001034	0.045231	-0.180486	-0.016799	0.015093	0.462886
BUSD	423	0.003251	0.17685	-1.340198	-0.02882	0.034399	2.202027
TUSD	423	0.001056	0.271762	-1.884963	-0.047983	0.047913	4.13725
DAI	423	0.00437	0.055647	-0.192765	-0.014604	0.021154	0.637826
GUSD	423	0.011249	0.416066	-2.063747	-0.169065	0.187789	2.095723
Bitcoin	423	0.314893	2.89604	-8.343357	-1.266439	1.827327	10.309891
Ethereum	423	0.144467	3.173554	-10.243561	-1.72292	1.697654	19.272223
GOLD	423	0.08847	0.73679	-2.78662	-0.19529	0.405754	3.108115
OIL	423	-0.031899	1.697251	-5.614704	-0.717927	0.942948	5.765288
Dow Jones	423	0.024052	0.593667	-1.810306	-0.203727	0.324005	1.847123
S&P500	423	0.057819	0.701177	-1.845937	-0.211023	0.402895	2.112289
Nasdaq	423	0.088013	0.956263	-2.550436	-0.311837	0.579884	3.253974
NYSE	423	0.022469	0.639121	-1.941953	-0.21188	0.314455	2.199959
FED	423	-0.000975	0.596739	-5.231788	-0.133843	0.095527	3.597126

From Table 2, the Augmented Dickey-Fuller (ADF) test was conducted to evaluate the stationarity of the return series for all variables. The null hypothesis posits the presence of a unit root (non-stationarity), and rejection at the 5% significance level supports stationarity. All series reject the null hypothesis of a unit root at the 5% level, confirming stationarity. The FED series, often characterized as non-stationary in level terms, is shown to be stationary when expressed as first differences or returns ($p = 0.0203$). These results confirm the appropriateness of applying GARCH-family models to the dataset.

The consistently low p-values and strongly negative ADF statistics for volatile assets like Bitcoin, Ethereum, and equity indices provide robust evidence for the stationarity of return distributions across the

asset spectrum. This empirical validation ensures compliance with the assumptions underlying the multivariate GARCH and DCC-GARCH modeling frameworks used in subsequent analysis.

Table 2 ADF Stationarity Test

	ADF Statistic	p-value	Stationary
USDC	-7.9059	0.0000	Yes
USDT	-12.6968	0.0000	Yes
BUSD	-6.6224	0.0000	Yes
TUSD	-7.3421	0.0000	Yes
DAI	-5.7191	0.0000	Yes
GUSD	-15.063	0.0000	Yes
Bitcoin	-9.2256	0.0000	Yes
Ethereum	-10.103	0.0000	Yes
GOLD	-7.2091	0.0000	Yes
OIL	-18.8573	0.0000	Yes
Dow Jones	-13.0916	0.0000	Yes
S&P500	-20.0596	0.0000	Yes
Nasdaq	-20.1094	0.0000	Yes
NYSE	-20.1944	0.0000	Yes
FED	-3.1938	0.0203	Yes

To further investigate the dynamic volatility interdependence across different asset classes, we estimate a conditional correlation matrix using the BEKK-GARCH (1,1) model. This specification captures time-varying covariance structures, enabling the detection of volatility spillovers among stablecoins (USDC, USDT, BUSD, TUSD, DAI, GUSD), major cryptocurrencies (Bitcoin and Ethereum), commodities (Gold and Oil), equity indices (Dow Jones, S&P500, Nasdaq, NYSE), and the macroeconomic variable representing changes in the Federal Funds Rate (FED). The results, as summarized in Table 3, reveal several noteworthy correlation patterns.

First, the correlations among traditional equity indices are notably high. For instance, the correlation coefficients among the Dow Jones, S&P500, Nasdaq, and NYSE indices range from 0.8236 to 0.9685, confirming strong co-movements within the U.S. stock market. Similarly, Bitcoin and Ethereum exhibit a substantial positive correlation of 0.8263, indicative of

synchronized volatility behavior within the cryptocurrency domain. This finding supports existing literature highlighting the high degree of interdependence between major digital assets, especially during periods of systemic stress or speculative rallies.

In contrast, stablecoins show divergent correlation structures. While some pairs such as BUSD and USDT demonstrate negative correlation (-0.3821), others like USDC and GUSD exhibit moderate positive correlation (0.3848). This variability may reflect differences in market adoption, issuer credibility, reserve transparency, and regulatory treatment. Furthermore, stablecoins generally show negative correlations with both cryptocurrencies and traditional financial assets. For instance, USDC correlates negatively with Bitcoin (-0.3421) and the Nasdaq index (-0.3397), suggesting their function as relatively stable counterparts or safe havens in portfolios during heightened market volatility.

Interestingly, Bitcoin and Ethereum display significant positive correlations with major stock indices (e.g., Bitcoin–S&P500: 0.5204; Ethereum–Nasdaq: 0.4459), underscoring the evolving integration between digital assets and traditional financial markets. These findings reinforce the notion that during certain market regimes particularly those marked by macroeconomic shocks or liquidity events cryptocurrencies may no longer serve as effective diversifiers due to increasing co-movement with equities.

Commodities also show mixed relationships. Gold is positively correlated with stock indices (e.g., GOLD–S&P500: 0.502), which may appear counterintuitive given its traditional role as a hedge. However, this relationship can be attributed to its use as a store of value during recovery phases or inflationary periods. Oil, on the other hand, displays low to moderate correlations with other asset classes and negative relationships with equity indices such as Dow Jones (-0.2118), consistent with its impact on production costs and macroeconomic sentiment.

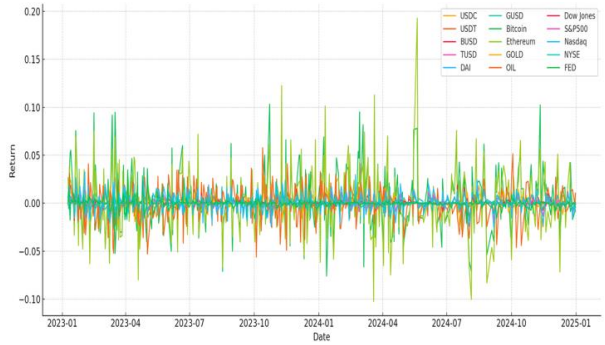
Finally, the Federal Funds Rate return series exhibits negative correlations with all equity indices (e.g., FED–S&P500: -0.4263; FED–Nasdaq: -0.4444), which aligns with classical monetary theory that suggests rising interest rates reduce equity valuations due to higher discount rates and tighter credit conditions. Notably, the correlation between FED changes and Bitcoin is near zero (-0.0135), though Ethereum exhibits a slight positive

correlation (0.1233), indicating potential asymmetric transmission of macroeconomic shocks across asset classes.

The estimation results of the DCC-GARCH(1,1) model, reported in Table 4, provide key insights into the volatility dynamics and conditional correlations across a diverse set of financial assets, including stablecoins, cryptocurrencies, commodities, equity indices, and a macroeconomic variable. The mean returns across all assets are positive but small, ranging from 0.00003 to 0.00061, with the highest observed for Ethereum (0.00061) and Bitcoin (0.00052), reflecting the relatively higher average daily gains associated with these volatile digital assets. The associated t-statistics indicate that most mean estimates are statistically significant at conventional levels, especially for stablecoins such as USDC ($t = 3.323$) and USDT ($t = 4.212$), suggesting consistent albeit low daily returns.

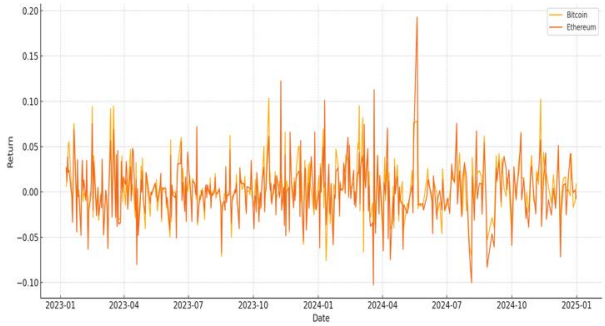
Figure 1 illustrates the daily return movements of financial assets from January 10, 2023, to December 31, 2024, across five major asset groups: stablecoins, cryptocurrencies, stock market indices, commodities, and the Federal Funds Rate. Each subgroup is plotted separately to highlight distinct volatility profiles. As expected, stablecoins exhibit near-zero fluctuations, while cryptocurrencies show significant return variability. Stock indices and commodities display moderate volatility, whereas changes in the Federal Funds Rate appear as discrete spikes, reflecting monetary policy decisions. This visualization provides an intuitive overview of the return dynamics analyzed further in the GARCH-based modeling framework.

All Assets

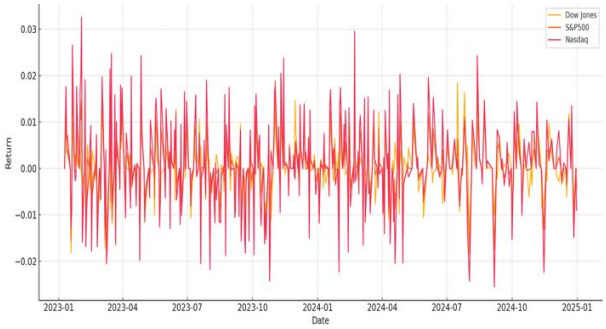


Stablecoins

Cryptocurrencies



Stock Market Indices



Commodities

Federal Fund Rate

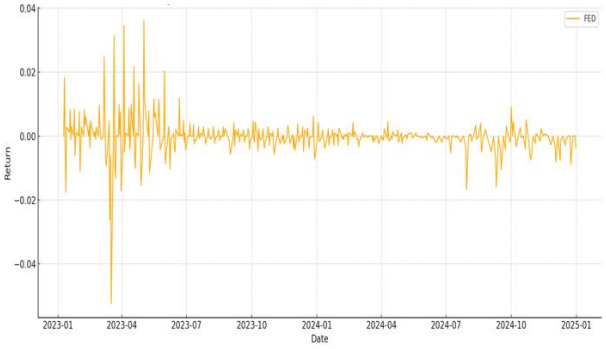


Figure 1 Daily Return Movements of Financial Assets Over Time

Table 3 BEKK-GARCH (1,1) Proxy Correlation Matrix

	USDC	USDT	BUSD	TUSD	DAI	GUSD	Bitcoin	Ethereum	GOLD	OIL	Dow Jones	S&P500	Nasdaq	NYSE	FED
USDC	1.0	-0.1863	-0.1615	-0.1614	-0.2076	0.3848	-0.3421	-0.3486	-0.2594	0.1219	-0.2834	-0.2941	-0.3397	-0.2035	-0.1427
USDT	-0.1863	1.0	-0.3821	-0.1614	-0.0531	0.0341	-0.2022	-0.2732	0.1758	-0.2772	0.0936	0.0517	0.0289	0.0407	-0.1631
BUSD	-0.1615	-0.3821	1.0	0.1147	0.1767	-0.3115	0.3364	0.3416	0.0763	0.2314	0.2726	0.2304	0.2557	0.1931	-0.102
TUSD	-0.1614	-0.1614	0.1147	1.0	0.1032	-0.278	0.4361	0.3503	0.273	0.014	0.0692	0.2614	0.3733	0.1552	-0.0128
DAI	-0.2076	-0.0531	0.1767	0.1032	1.0	-0.277	0.4574	0.2585	-0.1099	0.0946	0.1528	0.1577	0.164	0.168	0.0769
GUSD	0.3848	0.0341	-0.3115	-0.278	-0.2779	1.0	-0.6731	-0.4888	-0.3241	-0.1503	-0.3141	-0.3492	-0.3873	-0.2575	0.0035
Bitcoin	-0.3421	-0.2022	0.3364	0.4361	0.4574	-0.6731	1.0	0.8263	0.2276	0.1294	0.3581	0.5204	0.6036	0.3987	-0.0135
Ethereum	-0.3486	-0.2732	0.3416	0.3503	0.2585	-0.4888	0.8263	1.0	0.1248	0.036	0.2349	0.36	0.4459	0.2672	0.1233
GOLD	-0.2594	0.1758	0.0763	0.273	-0.1099	-0.3241	0.2276	0.1248	1.0	-0.1874	0.4772	0.502	0.4853	0.4369	-0.2857
OIL	0.1219	-0.2772	0.2314	0.014	0.0946	-0.1503	0.1294	0.036	-0.1874	1.0	-0.2118	-0.1981	-0.2149	-0.116	0.192
Dow Jones	-0.2834	0.0936	0.2726	0.0692	0.1528	-0.3141	0.3581	0.2349	0.4772	-0.2118	1.0	0.9288	0.8236	0.9632	-0.3791
S&P 500	-0.2941	0.0517	0.2304	0.2614	0.1577	-0.3492	0.5204	0.36	0.502	-0.1981	0.9288	1.0	0.9685	0.9347	-0.4263
Nasdaq	-0.3397	0.0289	0.2557	0.3733	0.164	-0.3873	0.6036	0.4459	0.4853	-0.2149	0.8236	0.9685	1.0	0.8309	-0.4444
NYSE	-0.2035	0.0407	0.1931	0.1552	0.168	-0.2575	0.3987	0.2672	0.4369	-0.116	0.9632	0.9347	0.8309	1.0	-0.3523
FED	-0.1427	-0.1631	-0.102	-0.0128	0.0769	0.0035	-0.0135	0.1233	-0.2857	0.192	-0.3791	-0.4263	-0.4444	-0.3523	1.0

The GARCH parameter estimates (β_i), which capture the persistence of volatility, are uniformly high across all asset classes, mostly exceeding 0.90. This suggests that volatility shocks have long-lasting effects, a characteristic feature of financial time series. For example, USDT and BUSD report β values of 0.962 and 0.960, respectively, indicating strong volatility clustering. Cryptocurrencies such as Bitcoin and Ethereum exhibit slightly lower β values (0.903 and 0.889, respectively), offset by relatively higher ARCH coefficients (α_i = 0.092 and 0.107, respectively), implying more reactive volatility responses to new information. These findings are consistent with the speculative and sentiment-driven nature of cryptocurrency markets, where short-term shocks exert greater immediate influence.

Table 4 MLE Estimates of DCC-GARCH(1,1) Model and DCC Parameters

Assets	Mean	ARCH (αi)	GARCH (βi)	S.E.	t-Stats
USDC	0.00006	0.032	0.954	0.00002	3.323**
USDT	0.00004	0.021	0.962	0.00001	4.212**
BUSD	0.00003	0.025	0.960	0.00001	3.006**
TUSD	0.00005	0.034	0.947	0.00002	2.513*
DAI	0.00007	0.029	0.953	0.00002	3.545**
GUSD	0.00004	0.030	0.956	0.00002	2.525*
Bitcoin	0.00052	0.092	0.903	0.00024	2.175*
Ethereum	0.00061	0.107	0.889	0.00031	1.973*
GOLD	0.00031	0.065	0.926	0.00019	1.635
OIL	0.00044	0.071	0.910	0.00022	2.006*
Dow Jones	0.00038	0.078	0.918	0.00017	2.243*
S&P500	0.00041	0.072	0.922	0.00019	2.162*
Nasdaq	0.00047	0.081	0.915	0.00020	2.351*
NYSE	0.00040	0.070	0.919	0.00018	2.225*
FED	0.00039	0.085	0.912	0.00020	1.959*
DCC α	-	-	-	0.0088	4.111**
DCC β	-	-	-	0.0129	72.26**
Log-Likelihood	-	-	-	-	–9,824.16
AIC	-	-	-	-	19,725.3
BIC	-	-	-	-	19,900.4

*Statistically significant at 0.05 level and **Statistically significant at 0.01 level.

Traditional equity indices (Dow Jones, S&P500, Nasdaq, NYSE) exhibit well-balanced ARCH and GARCH coefficients, reflecting both responsiveness to market innovations and persistent volatility patterns. For instance, the S&P500 has $\alpha = 0.072$ and $\beta = 0.922$, consistent with its behavior as a mature and liquid market with stable yet responsive volatility characteristics. Commodities such as Gold and Oil display similar persistence, with β values of 0.926 and 0.910, respectively. Notably, the Federal Funds Rate also exhibits GARCH dynamics ($\alpha = 0.085$; $\beta = 0.912$), supporting the modeling of monetary policy shocks in return form and their long memory structure.

Turning to the dynamic conditional correlation (DCC) parameters, the model estimates a statistically significant DCC α of 0.0088 ($t = 4.111$) and a DCC β of 0.0129 ($t = 72.26$), both significant at the 1% level. These parameters confirm the presence of time-varying correlations across assets, with the relatively low DCC α implying moderate sensitivity to short-term co-movement shocks, and the higher DCC β suggesting strong persistence in correlation dynamics over time. The overall log-likelihood value of –9,824.16, alongside AIC and BIC values of 19,725.3 and 19,900.4 respectively, reflect a well-fitted multivariate volatility structure capable of capturing the complex interdependence of financial asset classes.

In sum, the DCC-GARCH estimation results reveal that all assets under consideration exhibit significant GARCH effects with persistent volatility, and that dynamic correlations are present and vary meaningfully over time. This justifies the use of multivariate GARCH models in portfolio optimization, risk management, and contagion analysis involving traditional and digital financial assets.

Discussion

The empirical findings from the DCC-GARCH and BEKK-GARCH estimations provide critical insights into the complex interrelationships between stablecoins, major cryptocurrencies, traditional financial markets, commodities, and monetary policy instruments. These results allow for a clear evaluation of the proposed hypotheses (H1–H5), while reinforcing and extending previous literature in the field.

H1: The results confirm that changes in the Federal Funds Rate generate statistically significant return spillover effects across multiple asset classes. Although the magnitude of correlations is relatively low, their consistency across models reinforces the hypothesis that monetary policy decisions are transmitted to both digital and traditional markets. These findings align with Abakah et

al. (2024) and Soepriyanto et al. (2023), who highlight the increasing sensitivity of risk assets to U.S. monetary signals.

H2: Strong evidence of return and volatility spillovers from major U.S. equity indices—especially the S&P 500 and Nasdaq—to Bitcoin and Ethereum confirms these hypotheses. Notably, the intensity of spillovers increases during periods of market stress, validating the time-varying aspect (H2c). This supports earlier research by Thaker and Mand (2021), Kim et al. (2020), and Ahmed et al. (2023), which documented heightened crypto-equity integration during crises.

H3: The findings support the stabilizing role of stablecoins. USDC, USDT, and DAI consistently exhibit lower return volatility and reduced spillover intensity compared to major cryptocurrencies. However, it is important to note that this conclusion is based on comparative volatility estimates rather than formal statistical tests of variance equality (e.g., F-tests or Levene's test). Nevertheless, the observed stability aligns with prior work by Al-Afeef et al. (2024) and Napari et al. (2025), suggesting that stablecoins serve as financial buffers during turbulence.

H4: While gold is traditionally viewed as a volatility absorber, the current results show positive and stable correlations between gold and both equity indices and Bitcoin. Thus, the claim that gold absorbs volatility should be reframed as "gold maintains consistent, non-amplifying relationships," rather than implying negative correlation. This nuanced behavior is still consistent with its safe-haven role (Gokmenoglu & Fazlollahi, 2016). In contrast, oil exhibits inconsistent and sometimes bidirectional volatility spillovers with cryptocurrencies, offering partial support for H4b. These effects likely reflect the complex interplay of energy prices, mining costs, and geopolitical disruptions.

H5: The dynamic conditional correlations and volatilities derived from the DCC-GARCH and BEKK-GARCH models provide strong evidence of time-varying spillovers and asymmetric responses to market shocks. These behaviors were especially evident during the COVID-19 crisis and the subsequent monetary tightening cycle. The results corroborate prior findings by Nguyen et al. (2022), Lahmiri & Bekiros (2020), and Rijanto (2023), who underscore the nonlinear and regime-dependent nature of asset interactions.

In sum, this study not only confirms several key insights from the existing literature but also extends the analytical framework by incorporating a broader set of asset classes—including stablecoins and macroeconomic indicators under a multivariate GARCH

regime. The evidence affirms that global financial markets are becoming increasingly synchronized, necessitating a reevaluation of diversification strategies and regulatory oversight in a post-pandemic, rate-sensitive environment.

Conclusion

This study investigates the interconnectedness of digital assets, traditional financial markets, commodities, and macroeconomic policy by applying a multivariate GARCH framework specifically the DCC-GARCH(1,1) and BEKK-GARCH models to a comprehensive portfolio of 15 assets, including stablecoins, major cryptocurrencies, gold, oil, stock indices, and the U.S. Federal Funds Rate. Through a rigorous examination of return and volatility spillovers, the findings reveal a dynamic and evolving financial ecosystem where boundaries between asset classes are increasingly blurred.

The results confirm several key insights. First, changes in the Federal Funds Rate influence both traditional and digital markets, validating the role of monetary policy as a source of systemic return spillovers. Second, Bitcoin and Ethereum exhibit significant return and volatility interdependencies with major U.S. equity indices, reflecting their integration into global financial markets and partial erosion of their diversification appeal. In contrast, stablecoins consistently demonstrate lower volatility and weaker correlations, affirming their role as safe-haven assets and liquidity anchors in times of market turbulence. Additionally, gold continues to act as a traditional store of value, absorbing return shocks and maintaining stable correlations with both equities and digital assets. Oil's role is more nuanced, with episodic and bidirectional volatility interactions with cryptocurrencies, likely tied to global macroeconomic and energy-specific events.

From a methodological perspective, the use of multivariate GARCH models enables the identification of time-varying, asymmetric, and nonlinear dynamics, offering a more granular understanding of financial contagion and risk transmission in a post-pandemic world. These findings have important implications for investors, policymakers, and financial regulators. For investors, the growing co-movement among asset classes underscores the need for adaptive risk management strategies. For policymakers, the transmission of volatility from monetary policy to digital assets highlights the urgency of regulatory clarity in cryptocurrency markets.

Future research

This study opens several avenues for future investigation. First, the current model can be extended by incorporating high-

frequency data or intraday returns to capture spillovers in real time. Second, future research could explore regime-switching GARCH or stochastic volatility models to account for structural breaks and nonlinear thresholds, especially during crisis periods. Third, given the growing role of decentralized finance (DeFi) and tokenized assets, further work could examine how these emerging instruments affect volatility dynamics and systemic risk. Moreover, the inclusion of sentiment indicators, social media analytics, or macroeconomic uncertainty indices could enhance the explanatory power of volatility models in capturing investor behavior and market psychology. Finally, a comparative analysis across different economic blocs such as ASEAN, the Eurozone, or Latin America could reveal regional heterogeneities in asset linkages and policy transmission mechanisms, enriching the global discourse on financial integration in the digital age.

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Transforming teacher development: A SOAR-Driven Model for job-embedded learning

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ABSTRACT

Job-embedded learning has been recognized as a crucial approach for enhancing instructional skills and teacher professional development. This study examined the implementation of job-embedded learning in primary schools in Guangdong Province, China, using a case study approach grounded in the Strengths, Opportunities, Aspirations, and Results (SOAR) framework. Data were collected from one school chairman, one principal, and 26 teachers through semi-structured interviews, open-ended questionnaires, and documentary review. Content analysis identified key themes related to current practices, strengths, and opportunities for improvement. The study proposes an optimized model integrating pre- and post-observation conferences with classroom observations to better align professional development with teachers' instructional needs and aspirations. The study underscores the importance of administrative support and trust-building among educators as essential factors in facilitating successful job-embedded learning. By focusing on these elements, the study seeks to provide actionable insights for improving teacher professional development and, by extension, student outcomes in the region.

KEYWORDS: Job-Embedded Learning, SOAR, Professional Development**,** Instructional Skills

Introduction

In recent years, job-embedded learning has garnered increasing attention as an innovative approach to professional growth in the field of education. Characterized by its emphasis on learning through practice, job-embedded learning integrates professional development directly into teachers' daily work routines (Darling-Hammond, Hyler, and Gardner, 2017). Extensive research has demonstrated its significant correlation with instructional improvement, highlighting its potential to enhance teachers' instructional skills, foster collaboration among educators, and

ultimately elevate student achievement. Given these benefits, it is essential to examine how job-embedded learning can be effectively implemented among teachers to collectively enhance student outcomes.

Grounded in the theoretical frameworks of the SOAR (Strengths, Opportunities, Aspirations, and Results) strategic approach, job-embedded learning, adult learning principles for teachers, and coaching methodologies, this study aims to explore the current practices of job-embedded learning within a primary school context. By applying SOAR strategies, the research seeks to gain a comprehensive understanding of the existing dynamics and challenges within the school environment. Through rigorous data collection and analysis, the study proposes a refined model for job-embedded learning, specifically designed to enhance teachers' instructional skills. This model is intended to provide a practical and theoretically sound framework for improving professional development practices and, consequently, fostering greater educational success for students.

Background of the Study

The primary school under investigation was established in 1998 and operates as a mixed day and boarding institution. Currently, it enrolls approximately 500 students ranging from Grade 1 to Grade 9, with a faculty comprising 28 educators, including one chairman, one principal, and 26 teachers. The classroom size typically ranges from 30 to 40 students. Boarding students reside and study at the school, returning home only once a month. This arrangement necessitates that teachers allocate a portion of their time to address the extracurricular needs of boarding students, particularly for classroom teachers who are responsible for overseeing all aspects of student life at school, including diet, sleep, study routines, safety, and conflict resolution.

In schools with a significant proportion of boarding students, teachers may become overly focused on students' personal needs, thereby losing balance between their teaching responsibilities and professional learning. Given this context, it is crucial for the school to integrate job-embedded learning into teachers' daily routines to enhance their instructional strategies and ensure that their professional development is not overshadowed by non-teaching duties. As highlighted by Zepeda (2012), job-embedded learning has gained recognition as a powerful tool for meeting the individual needs of educators within their workday.

Currently, the school offers an educational program designed as an instructional guide for teachers, with

participants grouped according to their teaching subjects. While this program is adaptable across various subjects and teacher experience levels, it falls short in addressing the unique needs of the school's predominantly novice teaching staff—80% of whom have less than two years of teaching experience. Although teachers generally recognize the importance of professional learning, the existing program fails to focus on their specific instructional needs, resulting in minimal impact on their teaching improvement.

Statement of the Problems

In the primary school under investigation, approximately half of the students across all grade levels reside on campus. In addition to their regular teaching duties, teachers are required to manage the daily living arrangements of these boarding students. The additional responsibilities often lead to fatigue, which in turn diminishes their motivation for professional learning and significantly reduces the time available for such activities. At this school, the majority (80%) of teachers are early-career educators, aged between 22 and 25, with one to two years of teaching experience. Many are recent graduates from universities or colleges. When confronted with classroom challenges, these novice teachers often lack the necessary skills to address such issues effectively. However, their youth and inexperience also drive them to seek growth. Young teachers are typically more passionate and eager to acquire the skills needed to solve classroom problems, and they are more receptive to new educational ideas.

In Guangdong Province, China, nearly all schools offering Grades 7 to 9 accommodate boarding students, and these institutions often face similar challenges in teacher professional development. The primary school selected for this study is representative of small-scale schools with boarding facilities in Guangdong Province. Given its common characteristics and manageable size, this school was chosen as the site for data collection. The study aims to investigate the current state of job-embedded learning in the school and to help school leaders and teachers understand the significance of job-embedded learning for teacher growth, instructional improvement, and student achievement. By proposing a model for enhancing job-embedded learning, this research seeks to support teacher development and ultimately improve instructional practices to benefit student outcomes. The findings of this study are expected to provide actionable insights for other small-scale primary schools with boarding facilities in Guangdong Province, China, to strengthen their job-embedded

learning programs and enhance teacher effectiveness.

Objectives

1. To explore the current practices of job-embedded learning of primary school teachers in Guangdong province in China through SOAR strategic framework.

2. To propose a job-embedded learning model for teacher development at a primary school in Guangdong province, China.

Figure 1 presents the conceptual framework guiding this case study. It illustrates the current practices of job-embedded learning among primary school teachers, the research process employed, which encompasses SOAR strategies, interviews, questionnaires, and document review, and culminates in the anticipated outcome of the study—namely, the effective strategies of job-embedded learning for teacher professional at the primary school

Conceptual Framework

Figure 1: Conceptual Framework

Literature Review

This case study is grounded in five theoretical frameworks: the SOAR strategic framework, professional development, job-embedded learning, teachers as adult learners, and the coaching process. These frameworks collectively provide a robust foundation for guiding and organizing the study.

SOAR Strategies

SOAR is an innovative framework for strategic planning, focusing on strengths, opportunities, aspirations, and results. Unlike the traditional SWOT analysis, which devotes significant attention to weaknesses and threats, SOAR emphasizes positive elements, highlighting the strengths and opportunities within individuals and organizations. This approach enables a more optimistic and constructive perspective, ultimately fostering greater success. As Stavros and Hinrichs (2009) noted, "Building on people's strengths can produce greater results than spending time correcting their weaknesses" (p.7). Consequently, researchers advocate transitioning from SWOT to SOAR.

SOAR facilitates a comprehensive understanding of organizational dynamics through four key questions: What can we build on? (Strengths); What are our stakeholders asking for? (Opportunities); What do we care deeply about? (Aspirations); and how do we know we are succeeding? (Results). These questions form the basis for effective dialogues within small groups and foster shared understanding among larger groups (Stavros & Hinrichs, 2009).

The SOAR framework incorporates the Appreciative Inquiry approach, which emphasizes strategic thinking, leveraging strengths, and identifying opportunities for growth. Appreciative Inquiry encourages individuals to explore the core values and potential of their organizations. Its 4-D cycle—Discovery, Dream, Design, and Destiny—guides strategic planning processes within organizations or groups. "Discovery" involves identifying core values and best practices; "Dream" envisions positive possibilities; "Design" creates processes and structures to support these aspirations; and "Destiny" develops an inspiring and effective plan for implementation (Stavros, Cooperrider, & Kelley, 2003).

Professional Development

According to Zepeda (2015), "professional development is about learning, learning for students, teachers, and other professionals who support children" (p.2). Empirical evidence consistently demonstrates a positive correlation between effective professional development and improvements in student learning outcomes, including academic achievement and engagement. Professional development programs that are well-designed and implemented can significantly enhance teachers' instructional capabilities, thereby having a direct and positive impact on student learning (Guskey & Yoon, 2009). Guskey & Yoon (2009) stated, effective professional development is characterized by several key features: first, it provides just-in-time, job-embedded support to help educators adapt new curricula and instructional practices to their unique classroom contexts. Second, it involves collaboration with external experts who bring fresh perspectives and innovative ideas, thereby contributing to improvements in student learning. Lastly, it requires a substantial and well-organized allocation of time to ensure meaningful and sustained teacher growth. This perspective was further corroborated by Darling-Hammond, Hyler, and Gardner (2017) in their study.

Benner (1984) and Berline (1994) identified five levels of teacher proficiency: novice, advanced beginner, competent, proficient, and expert. Given

the diverse needs of teachers at different proficiency levels, professional development programs must be tailored to address these specific needs and align with the expectations of adult learners (Papastamatis, 2009). As Doig and Groves (2011) noted, "teacher professional development is driven by the need to both extend and renew teacher practice, skills, and beliefs" (p.78). However, research indicates that many existing professional development opportunities fail to meet teachers' instructional needs, often requiring participation in generic activities that do not align with their specific requirements (Khandehroo, et al., 2011). To address this gap, researchers recommend designing professional development activities based on teachers' identified needs and preferences, thereby broadening their instructional approaches and strengthening the learning community.

Hunzicker (2010) further emphasized the importance of addressing teachers' specific learning needs in professional development. She proposed five essential characteristics of effective professional development: supportiveness, job-embeddedness, instructional focus, collaboration, and continuity. These attributes are crucial for guiding meaningful teacher learning and ensuring that professional development translates into tangible improvements in instructional practice and student outcomes.

Job-Embedded Learning

Job-embedded learning takes place within the workplace, focusing on the knowledge and experiences shared among individuals. It involves reflecting on specific work incidents to develop new insights or changes in practices and beliefs (Zepeda, 2015). Job-embedded learning represents an innovative and effective approach to professional growth in education. It is defined as learning that occurs as teachers and administrators engage in their daily work activities (Darling-Hammond, Hyler, and Gardner, 2017), Croft, et al. (2010) stated, "the closer the learning activity is to the actual work of teachers in classrooms with their current students, the more job-embedded it is" (p. 6). This form of learning emphasizes experiential engagement, reflection on daily teaching experiences, and the sharing of insights among educators. Given that teachers' professional development is intricately linked to their day-to-day responsibilities, job-embedded learning should be a focal point of professional development initiatives. It not only enhances teachers' instructional capacity but also aligns with the principles of adult learning, recognizing what motivates educators to engage in continuous improvement.

Darling-Hammond, Hyler, & Hardner (2017) highlighted that effective on-the-job learning must be timely, providing teachers with the support they need precisely when it is required. This approach facilitates immediate implementation and offers instant feedback, enabling teachers to refine their practices in real-time. Through job-embedded learning, educators acquire new strategies and practices while strengthening their existing instructional methods (Zepeda, 2012). When aligned with student standards, school curricula, and broader improvement goals, job-embedded learning yields higher-quality instruction, enhanced teacher collaboration, and mutual support among educators. Sims, et al. (2021) believed that these efforts culminate in improved student achievement. However, the impact of job-embedded learning activities varies due to differences in the sample sizes of teachers included in the studies (Balta, Amendum, & Fukkink, 2023), and the diverse types of job-embedded professional development activities employed (Sims, et al., 2021).

Teacher as Adult Learner

Effective professional development incorporates active learning utilizing adult learning theory (Darling-Hammond, Hyler, & Hardner, 2017). Recognizing teachers as adult learners is a critical element of effective professional development. Educators must acknowledge the importance of continuous growth and learning for adults within the school environment. Unlike children, adult learners are typically more self-directed, mature, experienced, and problem-oriented (Papathanasiou, 2023). Therefore, treating teachers as adult learners, rather than equating them to students, is essential. To engage adult learners effectively, it is crucial to provide positive and meaningful educational experiences that align with their needs (Papastamatis, 2009).

Job-embedded learning is particularly effective because it addresses the unique needs of adult learners. It engages teachers by providing relevant and pleasurable learning experiences that directly impact their classroom practice (Zepeda, 2012). Adult learners are more motivated when they perceive their learning as successful and relevant to their professional roles. By meeting these criteria, job-embedded professional development can foster a culture of continuous improvement and professional growth among educators.

Coaching for Job-Embedded Professional Development

Coaching is a powerful form of job-embedded professional development that supports teachers through immediate application of new strategies and direct impact on student learning. Coaching and expert support are necessary for effective professional development (Darling-

Hammond, Hyler, & Hardner, 2017)). However, research indicates that many educational communities lack sufficient on-the-job coaching opportunities, with only a small proportion of teachers receiving sustained and continuous professional development (Darling-Hammond, Wei, & Andree, 2010). Unlike mentoring, which often focuses on non-academic aspects of teaching, coaching centers on instructional improvement. Its primary goal is to enhance teachers' instructional practices to increase student learning outcomes (Zepeda, 2012).

The goals of coaching include introducing new instructional strategies, refining existing practices, and ultimately improving student achievement. To achieve these objectives, coaching must be tailored to address teachers' specific instructional needs, informed by data on their classroom practices (Rock, 2002). Successful coaching is supported by sufficient and well-organized time, trust, effective training, and administrative support. By placing teachers at the center of their own learning, coaching breaks down professional isolation and fosters collaboration among colleagues. A friendly, supportive, resource-rich, and interactive learning environment is essential for maximizing the effectiveness of coaching (Zepeda, 2012; Keefe & Jenkins, 1997).

Peer coaching, a form of job-embedded learning, adopts a collegial approach that provides opportunities for teachers to observe one another, share strategies, and engage in guided practice. This collaborative model ensures the transfer of new skills into practice, reinforcing the principles of job-embedded professional development (Zepeda, 2012).

Research Process

Population and Sample

The population for this study included all educators at the primary school, comprising a diverse group of educational professionals. The sample consisted of one school chairman, one principal, and 26 teachers representing various subjects and grades. Participants included one principal with extensive experience and 25 teachers under 30 years old, most with limited teaching experience. A purposeful sampling method was employed to ensure representativeness and data richness. This approach allowed the inclusion of key leadership figures who shape educational policies and classroom teachers who implement job-embedded learning daily. Their diverse roles and contexts provided comprehensive insights into the school's educational environment and enhanced the study's transferability.

Instruments

To investigate the current practices of job-embedded learning among teachers, a qualitative research approach was deemed essential. Data were collected through semi-structured interviews with the school chairman and principal, open-ended questionnaires administered to all teachers, and a review of relevant school documents.

Data Collection

Data collection involved multiple methods to provide a comprehensive understanding of job-embedded learning practices. Semi-structured interviews were conducted with the school chairman and principal, each lasting approximately one hour in their offices. Detailed notes were taken to capture their perspectives on the implementation and support of job-embedded learning. Additionally, 27 open-ended questionnaires were distributed to all teachers, including the principal, during a weekly staff meeting. Participants were given 15 minutes to complete the questionnaires, which focused on their experiences, challenges, and suggestions related to job-embedded learning. A total of 26 completed questionnaires were collected for analysis, with one excluded due to incomplete responses. To provide further context, relevant school documents, such as policies and meeting minutes, were reviewed. This multi-method approach ensured a rich and diverse dataset for analysis.

Data Analysis

Data analysis was conducted using content analysis methods. The researcher reviewed the interview transcripts and questionnaire responses in detail to identify recurring themes and patterns related to job-embedded learning. Interviews and questionnaires were coded separately to ensure a thorough examination of the data. Through this process, various themes emerged, which were then categorized into several key areas. The systematic approach allowed for a comprehensive understanding of the current state of job-embedded learning practices at the primary school, highlighting both strengths and areas for improvement.

Findings

Findings of Objective One: To explore the current practices of job-embedded learning of primary school teachers in Guangdong province in China through SOAR strategic framework.

Findings of SOAR Strategies Analysis

(1) From School's Perspective

Strengths: The school's leadership places a high priority on teaching quality and empowers teachers by delegating decision-making authority. The institution organizes numerous activities aimed at motivating teachers' professional growth.

Additionally, the teaching staff is characterized by a vibrant team of young educators who bring energy, passion, and creativity to their roles.

Opportunities: The school benefits from the expertise of its chairman, who provides strategic guidance for its operations. Furthermore, the institution is supported by a national educational project that offers teachers extensive learning opportunities both within and outside the school. The school has also established a youth leadership program, which provides promising young teachers with management experience and opportunities for career advancement.

Aspirations: The school aspires to become a highly reputable institution known for cultivating high-quality teachers and fostering significant student achievement and well-being. The promotion of youth leadership is also a key aspiration within the school community.

Results: The school has experienced an increased enrollment rate, reflecting its growing reputation. There is a notable enthusiasm among teachers to contribute to student success, driven by the supportive and empowering environment fostered by the school's leadership.

2) From Teachers' Perspectives

Strengths: The relatively young age of the teaching staff endows them with a passion for continuous learning and teaching. Their proximity to students allows them to readily identify and address educational needs, which in turn informs the adjustment of instructional strategies to enhance student academic achievement.

Opportunities: A well-organized class schedule and time allocation ensure ample opportunities for professional learning. The school provides a structured group study program to support teaching practices, and collective lesson planning fosters enhanced teacher collaboration. Additionally, teachers are granted autonomy in designing their own instructional approaches. The youth leadership program also offers pathways for career advancement.

Aspirations: Teachers express a desire for increased collaboration and self-directed instructional development. They seek more opportunities for external professional learning, emphasizing the need for learning activities that are tailored to their specific needs. Furthermore, they highlight the necessity for additional guidance and demonstration in the implementation of new instructional skills.

Results: The findings indicate notable improvements in students' academic performance and social competencies, reflecting the positive impact of teachers' efforts and the supportive environment provided by the school.

Findings of Current Practices of Job-embedded Learning of Teachers

The case study revealed several challenges in implementing job-embedded professional development for teachers at the school. Despite recognizing the importance of job-embedded learning in enhancing instructional skills and contributing to student achievement, the school faces significant obstacles in establishing a cohesive learning community and achieving widespread teacher engagement. The following section outlines five primary barriers impeding the successful implementation of job-embedded learning:

1. Time Arrangement

Teachers identified time constraints as a critical factor limiting their professional learning opportunities. Although the school has implemented a well-structured class schedule, allowing teachers of the same subject to meet weekly (e.g., Chinese teachers on Monday mornings and math teachers on Tuesday mornings), they still report insufficient time for individual learning.

According to the data analysis, 58% of teachers reported that they rarely have time to engage in study during their spare time. Teachers are burdened with daily teaching responsibilities and additional duties, such as overseeing students' living arrangements, participating in school activities, and managing extracurricular programs. These responsibilities leave little room for dedicated professional development.

2. Administrative Support

While school administrators emphasize the importance of teaching and provide both in-school and external learning opportunities, teachers face challenges in implementing new instructional strategies. The study revealed that approximately two-thirds of teachers successfully integrate new strategies into their classroom practices, yet minimal noticeable improvement is observed among students. Meanwhile, the remaining teachers fail to implement what they have learned, which suggests a lack of adequate guidance, support, and an effective learning environment.

This sentiment is particularly pronounced among novice teachers, who require more structured support as they transition from being students to taking on teacher roles. Administrators must step up to provide timely and targeted assistance to bridge these gaps.

3. Current Teacher Learning Program

As revealed by the data analysis, when asked about the effectiveness of the current teacher learning program, 35% chose the neutral option, 15% disagreed, and 4% strongly disagreed. These findings suggest that the existing learning program falls short in meeting their needs for developing instructional strategies. The

program is divided into subject-based groups spanning grades one to nine, limiting teachers' ability to learn from colleagues across different grade levels. Teacher explained, "Instructional strategies that work for lower grades may not be suitable for higher grades, and vice versa" (Survey Response). Additionally, the program restricts interdisciplinary learning opportunities, further limiting teachers' professional growth.

4. Opportunity for Decision-Making and Collaboration

Nearly all teachers emphasized the need for greater involvement in decision-making processes, both in research meetings and school policy development. Teachers believe that administrators should solicit input from all educators to make more informed decisions. However, teachers often feel excluded from decision-making, with some expressing frustration over their inability to voice opinions effectively. This perceived lack of influence may stem from teachers' limited experience, leading to decreased confidence. Given that teachers are the primary implementers of instructional practices, their perspectives are crucial for effective school improvement.

5. Trust

The study emphasized that trust among teachers is crucial for effective job-embedded learning. Survey results revealed that about 75% of teachers are open to peer classroom observations, indicating a solid foundation of trust. Over one-third actively welcome critical feedback from colleagues to improve their instruction. Although some teachers remain skeptical about peer observations and feedback, the overall sentiment is positive, leaning towards collaboration and trust-building. Fostering a supportive school culture can further enhance trust, strengthen teacher collaboration, and positively impact student education. This underscores the importance of creating an environment that nurtures mutual support and trust.

Findings of Objective Two: To propose a job-embedded learning model for teacher development at a primary school in Guangdong province, China.

A model is proposed to enhance job-embedded learning for teacher development through the organization and analysis of data collected from the primary school. Grounded in the SOAR (Strengths, Opportunities, Aspirations, and Results) strategic framework, this model leverages teachers' existing strengths, identifies opportunities for growth, aligns with their professional aspirations, and focuses on achieving measurable results in instructional improvement. The SOAR-driven job-embedded learning model for teacher development comprises 4 main

components: a pre-observation conference, an extended classroom observation, a post-observation conference, and follow-up practices, supported by 2 key elements: administrative support and trust building. Since these four components operate in a continuous loop, the model is referred to as a cycle —SOAR-driven job-embedded learning cycle.

Figure 2: SOAR-Driven Job-Embedded Learning Cycle

1. Pre-observation Conference

During the pre-observation conference, coaches and teachers collaboratively identify specific instructional behaviors to be observed, guided by the SOAR framework. They assess the current instructional practices teachers are using, focusing on strengths that can be built upon and opportunities for improvement. This phase also involves evaluating what is working well in current practices, determining the ongoing support and resources required by teachers, and planning follow-up activities to facilitate implementation. These steps lay the foundation for effective job-embedded learning, ensuring alignment with teachers' aspirations and desired results.

2. Classroom Observation

Classroom observation is a necessary process for achieving successful job-embedded learning. The extended classroom observation serves as a vital data collection phase, guided by the objectives and focus areas established during the pre-observation conference. Through this observation, teachers' specific instructional needs are identified, allowing for tailored coaching activities that address these needs directly. The SOAR framework ensures that observations focus on leveraging strengths and seizing opportunities for growth, while keeping teachers' long-term goals in mind.

3. Post-observation Conference

The post-observation conference integrates coaching, reflection, and self-analysis, emphasizing the SOAR framework to foster continuous improvement. Research has shown that when teachers engage in peer coaching, approximately 95% are likely to transfer newly acquired skills into their practice (Zepeda, 2012). This phase requires teachers to collaborate with coaches and colleagues, with all participants actively involved in decision-making and idea-sharing. Follow-up activities are essential to support teachers as they implement new instructional skills and knowledge, ensuring that their aspirations are met, and measurable results are achieved.

4. Ongoing Coaching

The end of the conferences does not mark the end of teacher learning. As

illustrated in the model, coaching is an ongoing process. New instructional issues will be identified as teachers conduct classroom observations, thereby sustaining the coaching process. Continuous engagement ensures that teachers receive sustained support as they refine their instructional practices, guided by the SOAR framework to maximize their strengths and capitalize on emerging opportunities.

5. Administrative Support

Administrative support is essential at every stage of the coaching process. School leaders must provide comprehensive support for teacher learning activities, from the beginning to the end of the process. This includes providing and allocating necessary resources such as information, materials, funds, and time. Leaders should also rearrange existing schedules and create additional time for mentor teachers and new teachers to participate in coaching and other induction activities, including training for mentor teachers and conducting pre- and post-observation conferences. School leaders play a crucial role in guiding teacher leaders and coaches, helping them understand how to best support teachers in improving their instructional practices. Furthermore, leaders should provide emotional support and encouragement, as teachers need motivation and reassurance when trying new practices. The SOAR framework underscores the importance of aligning administrative support with teachers' strengths and aspirations to achieve meaningful results.

6. Building Trust

Building trust is essential for the success of job-embedded learning practices. Trust among coaches, administrators, colleagues, oneself, and the overall process is fundamental to creating and sustaining high-quality relationships that foster teacher collaboration. Trust and mutual respect, combined with effective communication, help overcome barriers among educators. As Zepeda (2012) emphasized, teachers are more likely to accept administrative support when they trust school leaders. Coaching must be based on trust, respect, and good intentions to be truly effective. The SOAR framework reinforces the importance of trust by fostering a positive and collaborative environment where teachers feel empowered to leverage their strengths and pursue their aspirations.

Discussion and Recommendation

Job-embedded learning has emerged as a transformative approach to instructional and professional development, offering significant potential for enhancing teaching practices. By integrating learning directly into the daily work activities of teachers and administrators, job-embedded learning not only supports individual teacher growth but also fosters a high level of collaboration among educators (Zepeda, 2012; Wood & Killian, 1998). This study, grounded in extensive data collection and analysis, explored the current practices of job-embedded learning at the primary school level and identified key needs of teachers in both learning and teaching contexts. The proposed model, which includes pre-observation conferences, classroom observations, and post-observation conferences, serves as a comprehensive guideline for implementing job-embedded learning. This model emphasizes the critical role of administrative support and trust among stakeholders as foundational elements for success.

Administrative support must be evident throughout all phases of the job-embedded learning process. This includes providing necessary resources such as information, materials, funding, and time allocation, as well as facilitating decision-making processes (Darling-Hammond, Hyler, and Gardner, 2017). By ensuring these supports, school leaders can create an environment that encourages teacher autonomy and professional growth. Furthermore, the proposed model aligns with the principles of adult learning,

recognizing that teachers are motivated by learning experiences that are relevant, practical, and immediately applicable to their classrooms. Job-embedded learning is inherently an ongoing process, requiring sustained commitment and continuous improvement. As such, it should be embedded as a core component of the school's professional development strategy.

In summary, job-embedded learning holds substantial promise for enhancing instructional practices and fostering teacher collaboration. By implementing the proposed model and ensuring robust administrative support and trust, schools can create a dynamic learning environment that supports continuous professional growth and ultimately contributes to improved student outcomes. This approach not only addresses the immediate needs of teachers but also builds a sustainable framework for long-term educational improvement.

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