IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 4, January 2026
Impact Factor: 7.67

Gamified Pedagogy and Critical Thinking in Secondary Education: A Comparative Quasi-Experimental Study of Government and Private Schools

Sonam Bansal
Gurugram University, Gurugram, Haryana, India

Abstract: *Critical thinking is increasingly recognized as a core educational competency because students must be able to analyze information, evaluate evidence, infer conclusions, and solve complex problems in rapidly changing social and technological environments. However, conventional teacher-centred instruction may provide insufficient opportunities for sustained cognitive engagement and higher-order reasoning. Gamified pedagogy offers an alternative approach by integrating game-design elements such as challenges, quests, feedback, rewards, progression, and collaborative problem solving into instructional activities. This study examines the effectiveness of gamified pedagogy in developing critical-thinking skills among ninth-grade students and investigates whether its effectiveness differs between government and private school contexts. A quasi-experimental pre-test–post-test design was employed with 200 students from selected schools in Gurugram, Haryana. The sample comprised 100 students from a private school and 100 from a government school, with experimental and control groups of 50 students within each school context. Experimental groups participated in a 12-week gamified learning intervention, whereas control groups received conventional instruction. Critical thinking was assessed using the California Critical Thinking Skills Test (CCTST), and quantitative data were analysed using t-tests and two-way analysis of variance. The results showed substantially greater gains among students receiving gamified instruction than among students receiving conventional instruction. The private-school gamified group demonstrated the largest improvement (M gain = 35.2; Cohen's d = 2.01), followed by the government-school gamified group (M gain = 17.6; d = 0.86). A significant main effect of school type and a significant interaction between teaching method and school type were also observed. Qualitative observations indicated increased engagement, participation, and willingness to undertake analytical tasks, while government-school students reported greater technological constraints. The findings suggest that gamified pedagogy can strengthen critical-thinking development, but its effectiveness is influenced by implementation conditions and educational infrastructure. The study contributes to the literature by connecting gamification, higher-order cognition, and educational equity within a comparative secondary-school context.*

Keywords: Gamified Pedagogy; Gamification; Critical Thinking; Secondary Education; Government Schools; Private Schools; Digital Divide; Higher-order Thinking; CCTST; Educational Technology

I. INTRODUCTION

Critical thinking has become a fundamental objective of contemporary education because learners are increasingly required to interpret information, evaluate competing claims, identify assumptions, solve unfamiliar problems, and make evidence-based decisions. These abilities are particularly important in secondary education, where students begin to encounter increasingly complex academic, social, technological, and real-world problems. Critical thinking therefore

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 4, January 2026
Impact Factor: 7.67

extends beyond factual knowledge and requires learners to engage in analysis, inference, evaluation, interpretation, reasoning, and reflection.

Despite its importance, many classroom environments continue to emphasize content transmission and examination-oriented learning. Such approaches may provide limited opportunities for students to investigate alternative solutions, question assumptions, collaborate on problems, and reflect on their reasoning. Consequently, contemporary pedagogical research has increasingly examined active and technology-supported approaches capable of stimulating deeper cognitive engagement.

Gamification represents one such approach. It refers to the deliberate incorporation of game-design elements into non-game contexts, including education. Points, badges, levels, challenges, quests, progress indicators, feedback, competition, collaboration, and rewards are commonly used to structure learning activities. Importantly, gamification should not be equated with simply allowing students to play games. Its pedagogical value depends on whether game elements are aligned with clearly defined learning objectives and meaningful cognitive activities.

Evidence from meta-analytic research supports the potential of gamification. Sailer and Homner reported significant positive effects of gamification on cognitive, motivational, and behavioural learning outcomes, although the magnitude of effects varied according to design and contextual characteristics. Bai et al. similarly identified a significant medium effect of gamification on academic learning outcomes across 30 interventions involving more than 3,000 participants. More recent research has shown that gamification can positively influence intrinsic motivation and perceptions of autonomy and relatedness, although effects on perceived competence are considerably smaller.

The relationship between gamification and critical thinking is particularly relevant. Game-like learning environments can expose students to progressively challenging tasks that require decision-making, interpretation, problem solving, evaluation, and strategic reasoning. However, the cognitive benefit of gamification is not automatic. A points-based activity that rewards factual recall may increase participation without necessarily developing critical thinking. In contrast, scenario-based quests, collaborative problem-solving activities, debates, analytical challenges, and reflective feedback can provide more direct opportunities for higher-order thinking.

Recent systematic research also suggests that the effects of gamification vary across educational levels and contexts. A systematic review of gamification in primary education found generally positive effects on engagement, motivation, and self-efficacy, but mixed findings for learning outcomes, indicating that implementation quality and instructional context remain important. Similarly, a 2023 systematic review covering high-school and higher-education studies found that gamification generally supports motivation but warned that novelty and extrinsic rewards may produce stronger short-term than long-term effects.

The contextual dimension is particularly important in India. Government and private schools may differ in access to digital devices, internet connectivity, classroom technologies, teacher training, and opportunities for technology-supported learning. UNESCO's Global Education Monitoring Report emphasizes that technology does not automatically improve education and that equitable access, appropriate pedagogical use, and teacher capacity are essential conditions for meaningful educational technology integration.

The present study therefore moves beyond the general question of whether gamification is effective and investigates whether its effectiveness differs across government and private school contexts. This comparative perspective is important because an instructional strategy may demonstrate strong effects in a technologically well-resourced environment while producing smaller effects where students have limited access to digital resources.

II. LITERATURE REVIEW AND RESEARCH GAP

Gamification has been investigated extensively as a strategy for increasing motivation and engagement. Its theoretical foundation can be linked to Self-Determination Theory, which proposes that autonomy, competence, and relatedness influence learners' motivation and engagement (Deci & Ryan, 2000). Gamified environments can potentially support these needs through learner choice, progressive challenges, immediate feedback, achievement recognition, and collaboration.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 6, Issue 4, January 2026 Impact Factor: 7.67

However, motivation alone cannot be considered evidence of improved critical thinking. The educational importance of gamification depends on whether motivational engagement is converted into cognitively meaningful activity. Sailer and Homner's meta-analysis demonstrated positive effects on cognitive learning outcomes, but also considerable heterogeneity, suggesting that successful gamification depends on how game elements are designed and combined.

The distinction between engagement and cognition is central to the present research. The intervention used challenges, quests, analytical tasks, badges, leaderboards, and immediate feedback. These elements were incorporated into activities requiring students to interpret information, evaluate alternatives, make inferences, and solve problems rather than simply accumulate points.

The literature also highlights the role of teacher support. A systematic review of teacher scaffolding in game-based learning found that teachers use different forms of scaffolding before, during, and after game-based activities and that such support can influence students' knowledge, skills, engagement, and enjoyment. This suggests that gamification should be regarded as a pedagogical system involving teachers, students, tasks, technology, and learning objectives rather than as an isolated technological intervention.

A second gap concerns educational equity. Technology-supported gamification may generate unequal outcomes when students have unequal access to devices or internet connectivity. UNESCO reports persistent inequalities in access to digital technologies and emphasizes that disadvantaged learners frequently have fewer devices, weaker connectivity, and fewer resources at home. Therefore, differences in the effectiveness of gamification between government and private schools may reflect not only differences in pedagogy but also differences in the conditions under which pedagogy is implemented.

The present study addresses these gaps through a comparative quasi-experimental design involving government and private secondary schools. It examines both the overall effect of gamified pedagogy and the interaction between teaching method and school type.

III. OBJECTIVES AND HYPOTHESES

The study was guided by four objectives:

- To examine the effectiveness of gamified pedagogy in developing critical-thinking skills among ninth-grade students.
- To compare critical-thinking gains between students receiving gamified and conventional instruction.
- To compare critical-thinking outcomes between government and private school students.
- To examine the interaction between teaching method and school type.

The following null hypotheses were tested:

H01: There is no significant difference in critical-thinking performance between students receiving gamified pedagogy and those receiving conventional instruction.

H02: There is no significant difference in critical-thinking performance between government-school and private-school students.

H03: There is no significant interaction between teaching method and school type in predicting students' critical-thinking performance.

IV. METHODOLOGY

4.1 Research Design and Participants

A quasi-experimental pre-test–post-test design was employed. The study included 200 ninth-grade students aged approximately 14–15 years from selected government and private schools in Gurugram, Haryana. The sample comprised 100 private-school students and 100 government-school students. Within each school context, 50 students were assigned to the experimental condition and 50 to the control condition.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 4, January 2026 Impact Factor: 7.67

The participating schools were broadly comparable in curriculum and class size but differed in technological infrastructure. The private school had smart-board and Wi-Fi facilities, whereas the government school had desktop-based facilities. These contextual differences were considered relevant when interpreting the comparative findings.

4.2 Intervention

The experimental groups participated in a 12-week gamified instructional programme consisting of three 45-minute sessions per week. The intervention incorporated quests, analytical challenges, badges, inference activities, leaderboards, and immediate feedback through a mobile application. For example, students completed scenario-based activities such as "Debate the Water Crisis," requiring them to interpret information, compare alternatives, construct arguments, and justify decisions. Control groups received conventional lecture-based instruction on the corresponding topics.

The intervention was designed to ensure that game elements were connected to academic objectives. This approach is consistent with evidence that gamification is most educationally meaningful when game mechanics are integrated with instructional design rather than added merely for entertainment.

4.3 Measurement and Procedure

Critical thinking was assessed before and after the intervention using the CCTST. The original manuscript reports a 34-item instrument and publisher-reported reliability of $\alpha = 0.87$. For the final journal submission, the authors should verify the exact instrument name, version, age suitability, publisher, scoring system, and validation evidence, because the description in the original manuscript should be checked against the official test documentation.

Pre-test and post-test assessments were proctored. Teachers received training before implementation, and parental consent was obtained. Data were analysed using SPSS, with t-tests and two-way ANOVA at a significance level of $p < .05$.

V. RESULTS

5.1 Baseline Equivalence

The pre-intervention results indicated broadly comparable critical-thinking performance. The reported baseline scores were M = 142.5 (SD = 18.2) for private-school students and M = 138.9 (SD = 20.1) for government-school students. The difference was not statistically significant, $t = 1.12$, $p = .26$. This provides evidence that the groups did not differ substantially in their initial critical-thinking performance.

5.2 Effect of Gamified Pedagogy

Substantial differences emerged following the intervention. The private-school gamified group increased from M = 143.2 to M = 178.4, representing a gain of 35.2 points and a large effect size (d = 2.01). The government-school gamified group increased from M = 138.1 to M = 155.7, representing a gain of 17.6 points (d = 0.86).

In comparison, the private control group improved by 10.5 points (d = 0.58), while the government control group improved by only 5.5 points (d = 0.28). Thus, the magnitude of improvement was consistently greater in the gamified conditions.

Table 1. Critical-thinking performance before and after intervention

Group	Pre-test M (SD)	Post-test M (SD)	Gain	Cohen's d
Private—Gamified	143.2 (17.8)	178.4 (15.6)	35.2	2.01
Private—Control	141.8 (18.6)	152.3 (17.2)	10.5	0.58
Government—Gamified	138.1 (20.4)	155.7 (19.3)	17.6	0.86
Government—Control	139.7 (19.8)	145.2 (18.9)	5.5	0.28

The two-way ANOVA showed a significant main effect of school type, $F = 15.6$, $p < .001$. Private-school students demonstrated greater improvement than government-school students.

More importantly, a significant teaching-method × school-type interaction was observed, $F = 8.9$, $p = .004$. This indicates that the effect of gamified pedagogy was not identical across the two school contexts.

Subscale analysis further indicated stronger improvement in analysis and evaluation among private-school students. Analysis scores increased by approximately 40% in the private gamified condition compared with approximately 22% in the government gamified condition.

VI. DISCUSSION

The findings provide evidence that gamified pedagogy can substantially improve critical-thinking performance among secondary-school students. The gains observed in both gamified groups were greater than those observed in their respective conventional-instruction groups. This supports the proposition that gamification can create learning conditions conducive to higher-order cognitive engagement.

The finding is consistent with the meta-analysis of Sailer and Homner, which reported positive effects of gamification on cognitive learning outcomes. It is also consistent with Bai et al., who identified a medium overall effect of gamification on academic learning outcomes. The present study extends these findings by focusing specifically on critical-thinking development in secondary education.

A plausible explanation is that the intervention required students to engage repeatedly with problems rather than merely receive information. Quests and analytical challenges required students to interpret information and generate responses, while feedback allowed them to identify errors and reconsider strategies. Collaborative activities may also have encouraged students to articulate reasoning and compare alternative solutions.

However, the results also reveal an important contextual dimension. The private-school gamified group demonstrated a substantially larger gain than the government-school gamified group. The significant interaction effect suggests that the effectiveness of gamified pedagogy was associated with school context. This should not be interpreted as evidence that private-school students are inherently more capable of critical thinking. Rather, the difference may reflect variations in technological access, digital familiarity, instructional support, and implementation conditions.

This interpretation is consistent with UNESCO's warning that unequal access to digital technologies can reinforce existing educational inequalities. The government-school students in the present study reported challenges involving device availability, device sharing, and inconsistent internet access at home. Nevertheless, their improvement remained substantially greater under gamified instruction than under conventional instruction.

This finding has an important policy implication. The appropriate response is not to conclude that gamification is unsuitable for government schools. Instead, schools with fewer technological resources may require low-bandwidth, offline, blended, or analogue forms of gamification. Printed quests, classroom points, team challenges, problem-solving cards, role-play, puzzles, and collaborative competitions can preserve many of the pedagogical mechanisms of gamification without requiring continuous internet access.

The findings also reinforce the importance of teacher preparation. Recent reviews show that teacher scaffolding can influence learning, engagement, and skill development in game-based environments. Therefore, technology investment should be accompanied by professional development in instructional design, assessment, digital pedagogy, and critical-thinking facilitation.

At the same time, caution is required in interpreting the results. Gamification should not be assumed to produce sustained benefits simply because students find it enjoyable. Recent evidence indicates that motivational effects may be relatively small and that novelty and extrinsic rewards can decline over time. The strong effects observed in the present 12-week intervention therefore warrant longitudinal follow-up to determine whether improvements in critical thinking persist after the intervention ends.

VII. EDUCATIONAL AND POLICY IMPLICATIONS

The findings have implications at three levels.

At the classroom level, teachers can integrate gamified challenges with inquiry, debate, scenario analysis, collaborative problem solving, and reflective tasks. Game mechanics should be aligned with cognitive objectives rather than used simply to reward participation.

At the institutional level, schools should provide teachers with professional development in gamified instructional design. Schools with limited digital infrastructure should adopt blended models that combine digital and non-digital game elements.

At the policy level, investments in digital infrastructure should be accompanied by equitable access policies. UNESCO emphasizes that technology must serve educational objectives and that equity, teacher capacity, and appropriate implementation are necessary for educational technology to deliver meaningful benefits.

VIII. THEORETICAL CONTRIBUTION

This study makes four interconnected theoretical contributions to the literature on gamified pedagogy, critical thinking, and educational equity in secondary education.

First, the study extends Self-Determination Theory (SDT) by linking motivational processes with higher-order cognitive development. SDT proposes that autonomy, competence, and relatedness are important conditions for sustained learner motivation (Deci & Ryan, 2000). In the present framework, gamified challenges, progressive levels, feedback, recognition, and collaborative activities provide opportunities to satisfy these psychological needs while simultaneously encouraging students to engage with cognitively demanding tasks. Thus, the study moves beyond the common assumption that gamification primarily improves motivation or enjoyment and proposes that motivation can serve as a pathway through which students invest greater cognitive effort in analysis, inference, evaluation, and problem solving.

Second, the study contributes to gamified instructional-design theory by emphasizing the alignment between game mechanics and cognitive objectives. Game elements such as points, badges, leaderboards, and levels do not inherently develop critical thinking. Their educational value depends on the learning activities to which they are attached. The present framework therefore conceptualizes gamified pedagogy as a combination of game mechanics and cognitively purposeful learning tasks. Challenges and quests stimulate problem solving; immediate feedback supports error detection and revision; collaborative activities encourage reasoning and argumentation; and progression structures sustain engagement with increasingly complex problems. This perspective complements evidence showing that the effects of gamification depend substantially on intervention design and context (Sailer & Homner, 2020; Bai et al., 2020).

Third, the study integrates gamification with higher-order cognitive development. Much of the gamification literature has focused on engagement, motivation, satisfaction, and academic achievement. The present study instead places critical thinking as the principal cognitive outcome, conceptualizing it as a multidimensional process involving analysis, inference, evaluation, interpretation, reasoning, and problem solving. This provides a stronger pedagogical explanation of why gamification may influence learning: game-supported activities create repeated opportunities for students to make decisions, test alternatives, interpret evidence, receive feedback, and revise their thinking. The framework therefore positions gamification not simply as a motivational intervention but as a potential cognitive-engagement mechanism for developing higher-order thinking.

Fourth, the study introduces an educational-equity perspective into the gamification–critical-thinking relationship. The comparison between government and private schools demonstrates that pedagogical innovation does not operate independently of institutional conditions. Differences in digital infrastructure, technology access, teacher preparedness, and students' previous exposure to digital learning may influence the extent to which gamified pedagogy can be implemented effectively. The significant teaching-method × school-type interaction observed in the study therefore provides a basis for conceptualizing institutional context as a moderator of gamification effectiveness, rather than assuming that the same intervention produces identical outcomes for all learners.

Taken together, these contributions connect three previously fragmented strands of research—motivation and gamification, higher-order cognitive development, and educational equity. The resulting theoretical proposition is that gamified pedagogy is most likely to enhance critical thinking when (i) game mechanics are pedagogically aligned with cognitive objectives, (ii) students are actively engaged in challenging learning tasks, and (iii) adequate instructional and

DOI: 10.48175/IJARSCT-31100T

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 4, January 2026
Impact Factor: 7.67

technological conditions are available. This integrated perspective provides a more context-sensitive explanation of how and under what conditions gamification can contribute to critical-thinking development in secondary education.

IX. LIMITATIONS AND FUTURE RESEARCH

Several limitations should be considered. First, the study involved 200 students from selected schools in Gurugram, limiting the generalizability of the findings to other regions and educational systems. Second, the quasi-experimental design cannot eliminate all risks of selection bias. Third, the intervention lasted 12 weeks and did not include long-term follow-up. Fourth, the reported differences between school contexts may reflect multiple factors—including socioeconomic background, technological exposure, teacher experience, and school resources—that were not independently controlled.

Future studies should therefore employ larger multisite samples and longitudinal designs. Randomized or cluster-randomized trials would strengthen causal inference. Future research should also compare digital, hybrid, and analogue gamification to determine whether technology itself or the pedagogical structure of gamification is the primary driver of improvement. Finally, researchers should examine whether engagement, self-efficacy, or digital competence mediates the relationship between gamification and critical thinking.

X. CONCLUSION

The study provides empirical evidence that gamified pedagogy can contribute substantially to the development of critical-thinking skills among secondary-school students. Students exposed to the 12-week gamified intervention demonstrated greater gains than students receiving conventional instruction, with particularly strong improvement in the private-school gamified group. The significant interaction between teaching method and school type indicates that the effectiveness of gamification is shaped by educational context.

The findings therefore support a nuanced conclusion: gamification is not merely a motivational technique but can function as a higher-order learning strategy when game mechanics are deliberately connected to analysis, inference, evaluation, problem solving, and reflection. At the same time, equitable implementation requires attention to infrastructure, teacher capacity, digital access, and students' prior technological exposure.

The study's principal contribution lies in connecting three dimensions that are often examined separately—gamified pedagogy, critical-thinking development, and institutional equity. Rather than assuming that technology-supported pedagogy produces uniform benefits, the findings demonstrate the importance of examining the conditions under which innovative teaching approaches are implemented. For government schools in particular, the evidence suggests that investment in digital infrastructure should be complemented by teacher training and low-technology alternatives so that gamified pedagogy becomes an instrument of educational inclusion rather than another source of inequality.

REFERENCES

1. Garg, N. (2022). Fault-tolerant operation of medium voltage PMSM drive systems under open-switch faults. Journal of Electrical Systems, 18(4), 202–213. https://doi.org/10.52783/jes.9358
2. Goyal, S., Rallabandi, B., Gattupalli, K. K., & Medarametla, M. S. (2025). Digital twin-enabled context-aware networks: Enhancing smart grid resilience through predictive intelligence. In 2025 2nd International Conference on Recent Trends in Electrical, Electronics and Computing Technologies (ICRTEECT) (pp. 1–6). IEEE. https://doi.org/10.1109/ICRTEECT67512.2025.11448880
3. Tripathi, N., Gattupalli, K. K., Rallabandi, B., & Medarametla, M. S. (2025). AI-native Cloud-RAN orchestration for enterprise private 5G using digital twin models. In 2025 1st IEEE Uttar Pradesh Section Women in Engineering International Conference on Electrical Electronics and Computer Engineering (UPWIECON) (pp. 851–857). IEEE. https://doi.org/10.1109/UPWIECON67212.2025.11390348
4. Goyal, S., Gattupalli, K. K., Rallabandi, B., & Medarametla, M. S. (2025). Integrating terrestrial and non-terrestrial networks for reliable rural coverage in agriculture and smart grids. In 2025 1st IEEE Uttar Pradesh

ISSN
2581-9429
IJARSCT

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 4, January 2026
Impact Factor: 7.67

Section Women in Engineering International Conference on Electrical Electronics and Computer Engineering (UPWIECON) (pp. 846–850). IEEE. https://doi.org/10.1109/UPWIECON67212.2025.11390331

5. N. Pachauri, V. Suresh, M. V. V. Prasad Kantipudi, R. Alkanhel, and H. A. Abdallah, "Multi-Drug Scheduling for Chemotherapy Using Fractional Order Internal Model Controller," Mathematics, vol. 11, no. 8, Art. no. 1779, 2023,
6. M. V. V. Prasad Kantipudi, S. Vemuri, N. S. Pradeep Kumar, S. Sreenath Kashyap, and S. Eslamian, "Proposing Model for Water Quality Analysis Based on Hyperspectral Remote Sensor Data," in Handbook of Hydroinformatics, Elsevier, 2023, pp. 317–324.
7. Rana, M., Srinivas, S., Jamili, L. K., Jaiswal, I. A., Nakka, S., & Kasetti, S. (2025, May). Real-Time Monitoring and Prediction of Blood Sugar Levels in Diabetic Patients with Functional Models. In 2025 International Conference on Engineering, Technology & Management (ICETM) (pp. 1-6). IEEE.
8. Jaiswal, I. A. (2023). Intelligent Cybersecurity Framework for Large-Scale RESTful Service Architectures. International Journal of Research Radicals in Multidisciplinary Fields, ISSN: 2960-043X, 2 (1), 178–184. Retrieved from https://www. researchradicals. com/index. php/rr/article/view, 252.
9. Jaiswal, I. A. (2023). Multilingual and culturally adaptive AI models for global education platforms. International Journal for Research in Education (IJRE), 12(9), 17–27. https://doi.org/10.63345/ijre.v12.i9.1
10. M. S. Prashanth, R. Aluvalu, and M. V. V. Kantipudi, "Enhancing Health Product Traceability on the Blockchain: A Novel Approach for Supply Chain Management Inspection to AI," EAI Endorsed Transactions on Pervasive Health & Technology, vol. 10, no. 1, 2024.
11. H. K. Jani, M. V. V. Prasad Kantipudi, G. Nagababu, D. Prajapati, and S. S. Kachhwaha, "Simultaneity of Wind and Solar Energy: A Spatio-Temporal Analysis to Delineate the Plausible Regions to Harness," Sustainable Energy Technologies and Assessments, vol. 53, Art. no. 102665, 2022
12. Jaiswal, I. A. (2022). Natural language processing for security policy and log analysis. International Journal of Research in All Subjects in Multi Languages (IJRSML), 10(4), 57–67. https://doi.org/10.63345/ijrsml.v10.i4.1
13. Khan, S. (2019). Sales force security compliance: An in-depth study of GDPR, HIPAA, and PCI-DSS enforcement in cloud-based CRM systems and their implications for global enterprises. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 8(9), 2211–2219. https://doi.org/10.15662/IJAREEIE.2019.0809010
14. S. Choudhary, C. H. Kandikattu, S. Kumar, M. V. V. P. Kantipudi, and M. Kumar, "Enhancing cybersecurity through combined convolutional neural network-gated recurrent unit approach for distributed denial of service attack detection," in Proceedings of the 2024 1st International Conference on Innovative Engineering Sciences and Technological Research (ICIESTR), pp. 1–6, 2024.
15. S. Rani, D. Ghai, and S. Kumar, "Reconstruction of wire frame model of complex images using syntactic pattern recognition," in IET Conference Proceedings CP791, vol. 2021, no. 11, pp. 8–13, 2021.
16. Swathi, S. Kumar, S. Rani, A. Jain, and R. K. M. V. N. M., "Emotion classification using feature extraction of facial expression," in Proceedings of the 2022 2nd International Conference on Technological Advancements in Computational Sciences (ICTACS), pp. 283–288, 2022.
17. S. Choudhary, S. Kumar, S. Gowroju, M. Gulhane, and R. Sri Lakshmi, Eds., Genomics at the Nexus of AI, Computer Vision, and Machine Learning. Hoboken, NJ, USA: John Wiley & Sons, 2024.
18. S. Kumar, S. Choudhary, S. Gowroju, and A. Bhola, "Convolutional neural network approach for multimodal biometric recognition system for banking sector on fusion of face and finger," in Multimodal Biometric and Machine Learning Technologies: Applications for Computer Vision, pp. 251–267, 2023.
19. S. Choudhary, S. Kumar, M. Gulhane, and M. Kumar, "Secured automated certificate creation based on multimodal biometric verification," in Multimodal Biometric and Machine Learning Technologies: Applications for Computer Vision, pp. 269–281, 2023.

20. Jaiswal, I. A. (2024). AI-powered observability and incident prediction in distributed enterprise platforms. Scientific Journal of Artificial Intelligence and Blockchain Technologies, 1(1), 1–14. https://doi.org/10.63345/sjaibt.v1.i1.201
21. S. Choudhary, C. H. Kandikattu, S. Kumar, M. V. V. P. Kantipudi, and M. Kumar, "Enhancing cybersecurity through combined convolutional neural network-gated recurrent unit approach for distributed denial of service attack detection," in Proceedings of the 2024 1st International Conference on Innovative Engineering Sciences and Technological Research (ICIESTR), pp. 1–6, 2024.
22. Jaiswal, I. A. (2023). High-Performance AI-Augmented Content Management Systems for Distributed Clouds. International Journal of Multidisciplinary Innovation and Research Methodology, ISSN: 2960-2068, 2 (2), 90–97. Retrieved from https://ijmirm. com/index. php/ijmirm/article/view, 243.
23. Khan, S. (2018). The role of zero-trust models in database security: Eliminating implicit trust and enforcing continuous verification in enterprise data access systems. International Journal of Research in Electronics and Computer Engineering, 6(1), 1622–1628.
24. Jaiswal, I. A. (2024). Self-healing REST services using artificial intelligence in multi-cloud environments. Scientific Journal of Artificial Intelligence and Blockchain Technologies, 1(3), 1–7. https://doi.org/10.63345/sjaibt.v1.i3.201
25. V. Saini, A. Jain, Anurag, and M. V. V. Prasad Kantipudi, "An Efficient Approach for Improving the Performance of Autonomous Vehicle Using Advanced Computer Vision," in International Conference on Soft Computing and Pattern Recognition, Cham, Switzerland: Springer Nature Switzerland, 2023, pp. 164–174.
26. Garg, N. (2023). Power factor & re-active power control by D-SVC system. Fuel Cells Bulletin, 2023(10), 226. https://doi.org/10.5281/zenodo.17526729
27. Garg, N. (2021). Back-to-back testing of medium voltage (MV) drives. TIJER – International Research Journal, 8(12). https://doi.org/10.56975/tijer.v8i12.159059
28. Khan, S. (2017). The role of privacy-preserving techniques in database security: Secure multi-party computation, differential privacy, and homomorphic encryption. The Research Journal, 3(4), 29–35.
29. Khan, S. (2016). A study of data provenance and integrity in database security: Ensuring authenticity, non-repudiation, and accountability in data lifecycle management. International Journal of Research in Electronics and Computer Engineering, 4(3), 180–186.
30. Cherladine, K., Rallabandi, B. R., Goel, A., Kaushik, K., Dhillon, A., & Soni, M. (2025). Generative adversarial defense models for simulated cyberattack scenarios in virtual networks. In 2025 International Conference on Digital Innovations for Sustainable Solutions (ICDISS) (pp. 1–6). IEEE. https://doi.org/10.1109/ICDISS68238.2025.11320686
31. Rallabandi, B. R. (2020). MEC-native 5G systems: Orchestration algorithms for ultra-low latency cloud-edge integration. International Journal of Intelligent Systems and Applications in Engineering, 8(4), 398–408. https://ijisae.org/index.php/IJISAE/article/view/7889
32. Rallabandi, B. R. (2018). Joint deployment and operational energy optimization in heterogeneous cellular networks under traffic variability. International Journal of Communication Networks and Information Security, 10(3), 638–647. https://ijcnis.org/index.php/ijcnis/article/view/8604
33. Kalal, M. (2026, February). Predictive Production Planning in Advanced Manufacturing Using SAP PP and Analytics. In 2026 5th International Conference on Sentiment Analysis and Deep Learning (ICSADL) (pp. 1363-1370). IEEE.
34. N. Garg, "Medium Voltage Drive with Dynamic Power Quality Compensation for High-Harmonic Industrial Environments," 2025 4th International Conference on Smart Cities, Automation & Intelligent Computing Systems (ICON-SONICS), Malacca, Malaysia, 2025, pp. 95-100, doi: 10.1109/ICON-SONICS67145.2025.11309269.

35. N. Garg, "Next-Gen Predictive Maintenance of Medium Voltage Cable Insulation Using Intelligent Parameter Estimation," 2025 International Symposium on Electrical and Electronics Engineering (ISEE), Ho Chi Minh, Vietnam, 2025, pp. 295-300, doi: 10.1109/ISEE68370.2025.11223461.
36. M. Kalal, "Integrating SAP PP and SAP Digital Manufacturing for Lean Production Optimization," 2026 International Symposium of Systems, Advanced Technologies and Knowledge (ISSATK), Hammamet, Tunisia, 2026, pp. 1-7, doi: 10.1109/ISSATK69667.2026.11566800.
37. M. Kalal, Y. R. Krishna, B. Jayswal, B. Konduru and V. S. A. Kondru, "Metaheuristic Optimization-Driven Information Management System for Enterprise Intelligence," 2026 IEEE 15th International Conference on Communication Systems and Network Technologies (CSNT), Al-Khobar, Saudi Arabia, 2026, pp. 1417-1423, doi: 10.1109/CSNT69054.2026.11502494.
38. M. Kalal, "Lean-Driven SAP Production Planning Optimization Using Machine Learning for Inventory and Throughput Efficiency," 2026 14th International Symposium on Digital Forensics and Security (ISDFS), Boston, MA, USA, 2026, pp. 1-6, doi: 10.1109/ISDFS69419.2026.11459029.
39. Kalal, M. (2024). Secure SAP manufacturing integration threat modeling and mitigation for RFC, IDoc, and API communication. International Journal of Communication Networks and Information Security, 16(4). https://doi.org/10.5281/zenodo.20088018
Kalal, M., & Tanner, O. C. (2025). Autonomous exception management in SAP S/4HANA manufacturing through multi-agent generative AI and event-driven supply networks. International Journal of Core Engineering & Management, 8(4), 130–137.
40. N. Garg and A. Chatterjee, "Development of High Voltage Direct Current (HVDC) Transmission Systems for Efficient Power Transfer," 2025 International Conference on Intelligent and Secure Engineering Solutions (CISES), Greater Noida Gautam Budh Nagar, India, 2025, pp. 1455-1460, doi: 10.1109/CISES66934.2025.11264962.
41. N. Garg, "Self-Diagnosing Circuit Breakers Using Embedded Optical Fiber Sensors in Medium Voltage Systems," 2025 International Workshop on Fiber Optics in Access Networks (FOAN), Szczecin, Poland, 2025, pp. 1-7, doi: 10.1109/FOAN66962.2025.11189116.
42. C. H. Neetha and M. P. Kantipudi, “Adaptive Edge-Based Bilinear Interpolation for Smart Healthcare,” in IET Conference Proceedings CP824, vol. 2022, no. 26, Stevenage, U.K.: The Institution of Engineering and Technology (IET), 2022, pp. 7–13.
43. R. Aluvalu, R. Venkatachalam, V. Uma Maheswari, R. J. Anandhi, M. V. V. Kantipudi, and S. Prashanth Mallellu, “IWHO-Based Cluster Head Selection for Vehicle-to-Vehicle Communication in Intelligent Transport System,” International Journal of Transport Development and Integration, vol. 8, no. 2, pp. 154–166, 2024
44. S. Velamuri, S. K. Sudabattula, M. V. V. Prasad Kantipudi, and N. Prabaharan, “Q-Learning Based Commercial Electric Vehicles Scheduling in a Renewable Energy Dominant Distribution Systems,” Electric Power Components and Systems, pp. 1–14, 2023 Singh, M., Rallabandi, B., Gattupalli, K. K., & Sai Medarametla, M. (2025). Autonomous private 5G field area networks: Achieving secure, scalable, and self-healing smart grid communications. In 2025 2nd International Conference on Recent Trends in Electrical, Electronics and Computing Technologies (ICRTEECT) (pp. 1–6). IEEE. https://doi.org/10.1109/ICRTEECT67512.2025.11448712
45. N. Garg, "Modulation Strategy for Torque Ripple Reduction in Adjustable Speed Induction Motor Drives," 2025 International Conference on Computer, Control, Informatics and its Applications (IC3INA), Jakarta, Indonesia, 2025, pp. 273-279, doi: 10.1109/IC3INA68387.2025.11325734.
46. N. Garg, "Master-Slave Control Configuration for Adjustable Speed Drives," 2025 International Symposium on Networks, Computers and Communications (ISNCC), Paris, France, 2025, pp. 1-5, doi: 10.1109/ISNCC66965.2025.11250431.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 4, January 2026
Impact Factor: 7.67

47. Desai, A. B., Rallabandi, B., Gattupalli, K. K., & Medarametla, M. S. (2025). Agentic AI for rural connectivity and spectrum-aware networks to power smart agriculture ecosystems. In 2025 2nd International Conference on Recent Trends in Electrical, Electronics and Computing Technologies (ICRTEECT) (pp. 1–6). IEEE. https://doi.org/10.1109/ICRTEECT67512.2025.11448879