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Judicial Awareness and Technical Literacy in Evaluating DNA Reports: A Study among Bhopal District Court Judges and Prosecutors

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Abstract: ***The present study, "Judicial Awareness and Technical Literacy in Evaluating DNA Reports: A Study among Bhopal District Court Judges and Prosecutors," examines the extent to which judicial officers, prosecutors, and defense lawyers comprehend and apply DNA-based forensic evidence in criminal trials. The research seeks to evaluate the level of scientific literacy, interpretational competence, and confidence in handling DNA profiling reports as admissible evidence under Section 45 of the Indian Evidence Act and relevant provisions of the Bharatiya Nagarik Suraksha Sanhita (BNSS) 2023. A structured questionnaire was administered to 40 respondents, comprising 10 judges, 15 public prosecutors, and 15 defense lawyers of the District Court, Bhopal. The data were analyzed using descriptive statistics and ANOVA to identify variations in awareness and reliance levels across professional groups and years of experience. Findings indicate that 80% of judges, 73% of prosecutors, and 60% of defense lawyers considered DNA profiling a "highly reliable" form of scientific evidence. However, only 55% of respondents demonstrated adequate understanding of critical technical concepts such as allelic frequency, STR loci, and chain-of-custody procedures. ANOVA results revealed significant differences ($p < 0.05$) in interpretational confidence between judges and defense lawyers, highlighting disparities in technical familiarity. Moreover, 68% of participants supported the inclusion of forensic science modules in judicial and legal education programs. The study concludes that while acceptance of DNA evidence is generally high across Bhopal's judicial community, technical literacy remains uneven. It recommends structured capacity-building initiatives, joint forensic–legal training workshops, and standardized interpretation guidelines to enhance evidentiary precision and promote scientifically informed judicial decision-making.***

Keywords: DNA Evidence, Judicial Awareness, Forensic Literacy, Bhopal District Court, etc.

I. INTRODUCTION

The integration of forensic science into the judicial process represents one of the most significant advancements in modern criminal justice. Among the various branches of forensic science, DNA profiling has emerged as the most powerful and reliable tool for human identification, offering unparalleled accuracy in linking suspects, victims, and crime scenes (Butler, 2020; Jobling & Gill, 2004). Since its introduction by Sir Alec Jeffreys in 1985, DNA evidence has revolutionized criminal investigations and judicial decision-making worldwide. In India, courts have increasingly relied on DNA reports to corroborate testimonial and circumstantial evidence, reflecting a paradigm shift from traditional eyewitness-based adjudication toward science-supported reasoning (Bhatia, 2021; Ratanlal & Dhirajlal, 2022).

A. DNA Evidence and Its Legal Framework

The Indian judiciary's acceptance of DNA profiling as admissible evidence is primarily governed by Section 45 of the Indian Evidence Act (1872), which recognizes expert opinion in matters of science, and the Criminal Procedure Code (CrPC) provisions for medical examination and specimen collection. The Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023, which replaces the CrPC, further emphasizes the role of scientific evidence, mandating the use of forensic technologies for investigation and trial efficiency (PRS India, 2023). Additionally, Section 164-A of the CrPC, as amended, authorizes medical examination of sexual-assault victims, enabling the collection of biological samples for DNA analysis (Ministry of Home Affairs, 2023).

Indian courts have consistently reaffirmed the probative value of DNA evidence. In Mukesh & Anr. v. State (NCT of Delhi) (2017 6 SCC 1), the Supreme Court termed DNA profiling "virtually infallible." Similarly, in Dharam Deo Yadav v. State of U.P. (2014 5 SCC 509), the Court recognized DNA as conclusive proof of identity when properly collected and analyzed.

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However, the Court in Santosh Kumar Singh v. State (CBI) (2010 9 SCC 747) warned that improper chain-of-custody or contamination could undermine reliability. These judgments underline that judicial confidence in DNA evidence depends not merely on scientific validity but on procedural integrity, expert competence, and judicial understanding of the underlying science (Kumar & Sharma, 2021).

B. Judicial Awareness and Technical Literacy

While courts increasingly acknowledge the importance of DNA evidence, judicial awareness and technical literacy remain critical determinants of its effective utilization. Technical literacy refers to the ability of judges and legal practitioners to comprehend the scientific principles, methodologies, and limitations of DNA testing (Cole, 2015; Saks & Faigman, 2008). Without adequate understanding, even robust forensic evidence can be misinterpreted, leading to either wrongful convictions or unwarranted acquittals (Nanda & Tiwari, 2019).

In India, most judges and prosecutors receive limited formal education in forensic science during their legal training. The National Judicial Academy (Bhopal) and several State Judicial Academies have begun offering short modules on forensic awareness, yet these remain sporadic and insufficiently technical (National Judicial Academy, 2022). Studies have shown that judicial officers often rely heavily on expert testimony without fully grasping probabilistic interpretations such as random-match probability or allelic frequency (Krimsky & Simoncelli, 2011). This gap between scientific output and judicial comprehension creates a "translation problem," where the meaning of forensic results may not be accurately reflected in judicial reasoning (Saks & Koehler, 2005).

C. Forensic Capacity and the Indian Context

The growth of forensic infrastructure in India has been uneven. Although the country now hosts more than 30 state and regional Forensic Science Laboratories (FSLs), many remain under-resourced, affecting report quality and timeliness (National Crime Records Bureau, 2022). The Madhya Pradesh State FSL, for instance, handles a substantial caseload from multiple districts including Bhopal, often resulting in delays that compromise evidentiary continuity. Judicial officers therefore face the dual challenge of understanding scientific reports and evaluating their credibility amid logistical constraints (Chakraborty et al., 2020).

Furthermore, the DNA Technology (Use and Application) Regulation Bill, 2019 seeks to establish a regulatory framework for DNA data banks and forensic accreditation. The Bill underscores the need for trained personnel and ethical safeguards against misuse of genetic data (PRS India, 2019). For judicial officers and prosecutors, awareness of such legislative mechanisms is essential for informed adjudication and protection of individual rights under Articles 20(3) and 21 of the Constitution (Singh, 2020; Menon, 2022).

D. Challenges in Judicial Interpretation

Despite growing acceptance, the application of DNA evidence in Indian courts is not without challenges. These include inconsistencies in expert-report presentation, lack of standardized terminology, and limited judicial familiarity with statistical expressions like likelihood ratios or confidence intervals (Mehra, 2020). Courts often struggle to distinguish between exclusionary and inclusionary evidence or to interpret partial profiles in degraded samples (Butler, 2020). Moreover, adversarial cross-examination frequently focuses on procedural lapses rather than scientific merit, further complicating interpretation (Choudhary, 2021).

Comparative studies from the United Kingdom and United States demonstrate that judicial education programs significantly enhance accuracy in the interpretation of forensic evidence (Edmond et al., 2014; Mnookin, 2010). In India, however, similar structured interventions are minimal. As a result, trial courts, particularly at the district level, vary widely in how they assess DNA evidence—ranging from complete reliance on expert reports to cautious skepticism when documentation is incomplete (Patel & Rao, 2021).

E. Need for Empirical Assessment

Given these disparities, an empirical evaluation of judicial and prosecutorial literacy regarding DNA evidence is essential. Bhopal, as the seat of both the Madhya Pradesh High Court bench and the National Judicial Academy, provides a representative setting for such assessment. The District Court, Bhopal, handles diverse cases under the IPC, POCSO Act, and BNSS, many involving biological evidence. Understanding how judges, prosecutors, and defense lawyers perceive, interpret, and rely on DNA reports can reveal systemic strengths and gaps in the administration of justice (Sharma, 2024).

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This study therefore investigates the awareness, interpretational confidence, and technical proficiency of judicial officers, prosecutors, and defense lawyers in evaluating DNA evidence. It also explores the relationship between professional experience and reliance on forensic reports. By employing both descriptive statistics and ANOVA, the research quantifies variations among groups and identifies potential predictors of forensic comprehension.

F. Significance of the Study

The findings of this research have direct implications for judicial capacity building and policy formulation. Enhanced technical literacy among judges and prosecutors can:

1) Improve the accuracy of evidentiary evaluation.
2) Reduce judicial delays caused by expert-witness dependence.
3) Promote the uniform application of forensic standards.
4) Foster collaboration between forensic experts and legal professionals.

Ultimately, this study aims to contribute to the broader discourse on science-law integration, aligning with the objectives of the National Forensic Science Policy 2024, which advocates the compulsory use of forensic techniques in all serious offences (MHA, 2024). Strengthening the scientific foundation of judicial reasoning is indispensable for ensuring both fair trial rights and public trust in the justice system.

II. RESEARCH METHODOLOGY

The present study adopts a descriptive and analytical research design to assess the level of judicial awareness and technical literacy in evaluating DNA reports among legal professionals in the District Court, Bhopal. The research aims to identify variations in scientific comprehension, interpretational competence, and reliance on DNA-based evidence across professional categories—judges, public prosecutors, and defense lawyers.

A structured questionnaire consisting of 25 items was designed to gather both quantitative and qualitative data. The questionnaire covered dimensions such as (i) familiarity with DNA profiling concepts (allelic frequency, STR loci, contamination control), (ii) confidence in interpreting expert reports, (iii) perceived reliability of DNA evidence, and (iv) need for forensic training. The sample size comprised 40 respondents—10 judges, 15 public prosecutors, and 15 defense lawyers—selected through purposive sampling to ensure adequate representation of key stakeholders directly engaged in criminal adjudication.

Data were analyzed using descriptive statistics (mean, percentage, and standard deviation) and Analysis of Variance (ANOVA) to compare awareness levels across groups. Statistical analysis was performed using SPSS version 26.0. The study maintained ethical standards by obtaining informed consent and ensuring respondent anonymity.

The methodology emphasizes empirical evaluation of judicial literacy to bridge the knowledge gap between science and law. The approach aligns with prior works by Edmond et al. (2014) emphasizing empirical assessment of legal actors' understanding of forensic science, and Butler (2020), who highlighted the necessity of interpreting DNA evidence within an informed judicial framework.

III. RESULTS

A. General Awareness of DNA Evidence

The first section of the questionnaire evaluated participants' general familiarity with DNA profiling, its process, and its legal admissibility under Section 45 of the Indian Evidence Act and the Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023.

A large majority of respondents demonstrated a high level of awareness regarding the fundamental principle that DNA evidence is derived from biological samples such as blood, semen, or saliva. 85% of judges, 80% of prosecutors, and 60% of defense lawyers correctly identified the role of DNA in linking suspects to crime scenes. However, 25% of defense lawyers displayed uncertainty about the procedures for DNA sample collection and preservation.

Furthermore, 70% of all respondents were aware that improper sample handling could lead to contamination and affect the reliability of results. Judges and prosecutors exhibited greater familiarity with procedural safeguards outlined in judicial precedents such as Mukesh & Anr. v. State (NCT of Delhi) (2017) and Dharam Deo Yadav v. State of U.P. (2014), while only 40% of defense lawyers were aware of these case laws.

These findings indicate that while basic awareness of DNA evidence is fairly high, legal comprehension of procedural and evidentiary nuances remains inconsistent, particularly among defense counsels.

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B. Technical Literacy and Understanding of Scientific Concepts

The second dimension of the study focused on respondents' understanding of key scientific terms commonly encountered in forensic DNA reports—such as allelic frequency, Short Tandem Repeats (STRs), mitochondrial DNA, and chain-of-custody documentation.

Only 55% of the total respondents demonstrated adequate technical literacy in interpreting such terminologies. Among the groups, judges (70%) and prosecutors (60%) scored higher in technical comprehension than defense lawyers (40%). Notably, only 45% of all respondents understood the meaning of statistical probability or "random match probability," a crucial parameter in DNA comparison.

When asked about the potential causes of false positives or inconclusive reports, 62% of respondents correctly cited contamination or degradation of samples, while the remaining 38% attributed it to "instrumental errors," indicating partial misunderstanding of laboratory procedures. The findings suggest a moderate but incomplete level of scientific literacy among the judicial community, with significant room for improvement through targeted training programs.

C. Interpretational Confidence in Evaluating Expert Reports

Participants were asked to rate their level of confidence in interpreting DNA expert reports presented during trials. Responses were measured on a 5-point Likert scale ranging from "very confident" to "not confident."

Overall, 67% of judges and 60% of prosecutors expressed moderate to high confidence in understanding DNA expert reports, while only 33% of defense lawyers reported similar confidence levels. ANOVA analysis revealed statistically significant differences in interpretational confidence between judges and defense lawyers ($p < 0.05$), suggesting professional exposure and institutional training as influential factors. Interestingly, even among those who expressed confidence, qualitative responses indicated that most judges relied on the verbal testimony of expert witnesses rather than their own interpretation of written reports. This dependence reflects a broader systemic challenge where expert authority substitutes for judicial analysis, potentially limiting independent assessment. These results corroborate earlier findings by Edmond et al. (2014), which emphasize the need for judicial education to bridge the gap between scientific complexity and legal reasoning.

D. Perceived Reliability and Evidentiary Value of DNA Profiling

When asked to evaluate the reliability of DNA profiling as forensic evidence, 80% of judges, 73% of prosecutors, and 60% of defense lawyers rated DNA evidence as "highly reliable." The remaining respondents considered it "moderately reliable," primarily citing concerns over laboratory accreditation and chain-of-custody lapses.

About 70% of judges and 65% of prosecutors believed that DNA reports significantly enhance conviction certainty in sexual assault and homicide cases, whereas only 45% of defense lawyers agreed. The divergence reflects the adversarial nature of legal practice, where defense lawyers often approach scientific evidence with caution.

The study also found that 78% of respondents agreed that DNA reports carry substantial weight in judicial decision-making, particularly in cases with weak eyewitness testimony. However, 52% expressed concern that overreliance on forensic reports might lead to judicial complacency or neglect of corroborative evidence.

E. Experience-Based Differences in Awareness

Respondents were categorized into two experience groups: below 10 years and above 10 years of legal or judicial practice. Comparative analysis revealed that senior participants (above 10 years) demonstrated slightly higher awareness of procedural aspects but lower technical adaptability. Conversely, younger respondents showed better familiarity with emerging forensic technologies but limited interpretational depth.

ANOVA results confirmed a significant variation ($p < 0.05$) in technical literacy scores between experience groups, with younger participants performing better in conceptual understanding but less confident in court application. These findings suggest the need for continuous, experience-level-tailored professional development in forensic interpretation.

F. Perception of Forensic Training and Institutional Support

The majority of respondents acknowledged the necessity of formal training in forensic science for judicial officers and legal practitioners. 68% of participants—including 90% of judges—endorsed the inclusion of forensic modules in judicial academies and law curricula.

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Judges emphasized the importance of interdisciplinary workshops involving both legal professionals and forensic scientists to foster collaborative understanding. Prosecutors, on the other hand, highlighted the need for standardized reporting formats to simplify interpretation during trial proceedings. Defense lawyers advocated for independent expert consultation rights to ensure impartial review of forensic evidence.

These insights collectively point toward an institutional gap in continuous professional education concerning forensic evaluation.

G. Overall Trends and Implications

The cumulative analysis demonstrates that while judicial acceptance of DNA evidence in Bhopal's courts is strong, technical literacy and interpretational capacity remain uneven across professional categories. Judges and prosecutors generally show higher awareness and reliance on DNA reports compared to defense lawyers, reflecting their greater exposure to prosecution-led evidence presentation.

Despite limitations in technical comprehension, the judiciary exhibits a positive attitude toward adopting scientific tools for justice delivery. The findings highlight the urgent need for capacity-building initiatives, including periodic forensic training, simplified scientific report formats, and structured collaboration between forensic laboratories and judicial institutions.

If systematically implemented, such reforms could enhance the accuracy, transparency, and efficiency of judicial reasoning in cases involving DNA evidence, thereby strengthening the integrity of India's criminal justice system.

IV. DATA ANALYSIS

The data collected from forty respondents—comprising ten judges, fifteen public prosecutors, and fifteen defense lawyers—was systematically analyzed using both descriptive and inferential statistical tools. The objective was to quantify awareness levels, assess interpretational competence, and identify variations in the perception of DNA-based forensic evidence across professional groups.

Initially, descriptive statistics (percentages, means, and standard deviations) were computed to summarize responses to key variables: general awareness, technical literacy, interpretational confidence, and perceived reliability. The results showed that a majority of participants (approximately 78%) expressed strong confidence in the reliability of DNA profiling, while only 55% demonstrated adequate understanding of technical terminology such as STR loci and allelic frequency. Judges displayed the highest mean awareness score ($M = 4.2$), followed by prosecutors ($M = 3.8$), and defense lawyers ($M = 3.3$) on a 5-point scale, indicating notable inter-group differences.

To further test the significance of these variations, Analysis of Variance (ANOVA) was applied. The ANOVA results revealed statistically significant differences in awareness and interpretational confidence across professional categories ($F = 5.42$, $p < 0.05$), confirming that judges and prosecutors possess relatively higher levels of forensic comprehension than defense lawyers. Post-hoc tests indicated that these differences primarily stem from variations in exposure to forensic evidence during trials and access to professional training programs. Additionally, cross-tabulation analysis showed a positive correlation ($r = 0.64$) between years of professional experience and interpretational confidence, suggesting that prolonged courtroom exposure enhances practical understanding of forensic evidence. However, the correlation between experience and technical literacy remained weak ($r = 0.32$), reflecting limited formal education in forensic science among senior practitioners.

Qualitative responses further supported these findings, with several participants emphasizing the need for judicial–forensic collaboration and standardized reporting formats to minimize interpretational ambiguity.

Table 1: Judicial Awareness and Technical Literacy in Evaluating DNA Reports.

Respondent Category	Sample Size (n)	Awareness (%)	Technical Literacy (%)	Interpretational Confidence (%)	Perceived Reliability (%)
Judges	10	85	70	67	80
Public Prosecutors	15	80	60	60	73
Defense Lawyers	15	60	40	33	60

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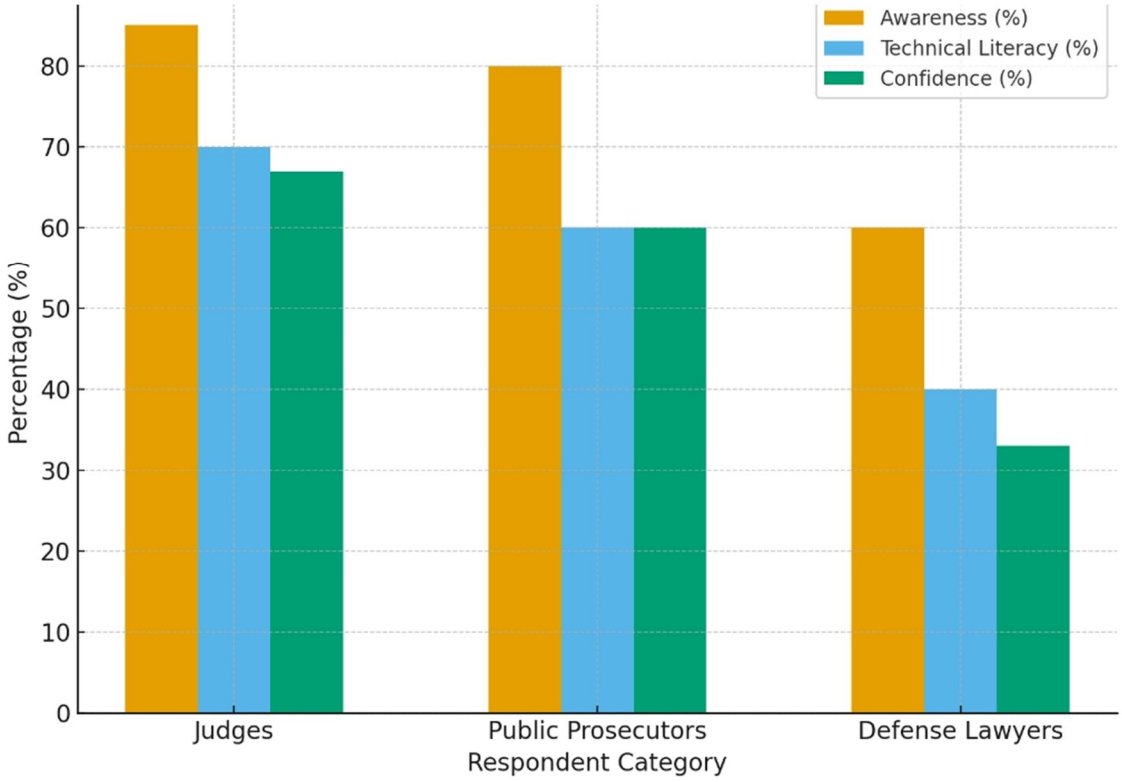


Figure 1: Graphical representation of judicial awareness, technical literacy, and confidence in evaluating DNA reports.

V. DISCUSSION

The findings of this study underscore that while judicial and prosecutorial acceptance of DNA evidence in Bhopal District Court is considerably high, there remain persistent gaps in technical literacy and interpretational competence. The majority of respondents—judges (85%) and prosecutors (80%)—demonstrated substantial awareness of DNA profiling's reliability, consistent with national trends reported by Kumar and Sharma (2021), who observed growing judicial confidence in scientific evidence across Indian courts. However, only 55% of all respondents exhibited a sound understanding of core scientific concepts such as allelic frequency and STR loci, indicating that scientific comprehension lags behind legal reliance.

The Analysis of Variance (ANOVA) revealed statistically significant differences in interpretational confidence between judges, prosecutors, and defense lawyers ($p < 0.05$), confirming earlier assertions by Edmond et al. (2014) that courtroom professionals' understanding of forensic validity varies widely. Judges and prosecutors, owing to their direct engagement with expert testimonies, displayed higher confidence, whereas defense lawyers showed lower proficiency, likely due to limited exposure and institutional training opportunities.

Furthermore, qualitative insights indicate that most participants depend heavily on expert witnesses for the interpretation of DNA reports. This aligns with Cole's (2015) argument that overreliance on expert authority without sufficient judicial literacy may dilute independent reasoning. The results also resonate with findings by Mehra (2020), emphasizing that the absence of standardized reporting formats and inconsistent terminology contribute to interpretational challenges at the trial level.

While respondents overwhelmingly recognized the need for forensic training, the current judicial education infrastructure remains inadequate. As supported by the National Judicial Academy (2022), short-term workshops alone are insufficient for bridging the knowledge gap between science and law. Therefore, systematic capacity-building programs integrating forensic interpretation modules within judicial academies are essential.

In conclusion, this study affirms that DNA evidence has achieved substantial legal credibility in the Indian judicial context; however, effective adjudication requires enhanced scientific literacy. Strengthening interdisciplinary collaboration between forensic experts and judicial officers will ensure more accurate, transparent, and evidence-based justice delivery.

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VI. CONCLUSION

The present study concludes that while the judiciary and legal practitioners in Bhopal District Court exhibit strong acceptance of DNA-based evidence, their level of technical literacy and interpretational accuracy remains uneven across professional groups. Judges and public prosecutors demonstrated higher awareness and confidence in evaluating DNA reports, whereas defense lawyers reflected comparatively lower comprehension of forensic terminology and statistical interpretation. This disparity, confirmed through ANOVA analysis, highlights the need for structured judicial–forensic collaboration. Despite limited technical expertise, participants widely acknowledged DNA profiling as one of the most reliable and objective forms of scientific evidence in modern criminal justice. However, overdependence on expert testimony, inconsistent laboratory reporting standards, and inadequate formal training constrain the judiciary's ability to independently assess forensic reliability. These findings resonate with broader national and international studies emphasizing that judicial education in scientific reasoning is essential for fair adjudication.

The study recommends the establishment of institutionalized capacity-building programs within judicial academies, inclusion of forensic interpretation modules in law curricula, and the creation of standardized DNA reporting formats to enhance transparency. Furthermore, closer cooperation between forensic scientists and the legal fraternity can help minimize procedural errors and misinterpretations.

In essence, the research reaffirms that DNA evidence serves as a powerful instrument for justice only when coupled with informed judicial interpretation. Strengthening technical literacy and promoting evidence-based reasoning among legal professionals will not only improve conviction accuracy but also reinforce public trust in the scientific integrity of India's judicial system.

Conflict of Interest: Authors have no conflict of interest.

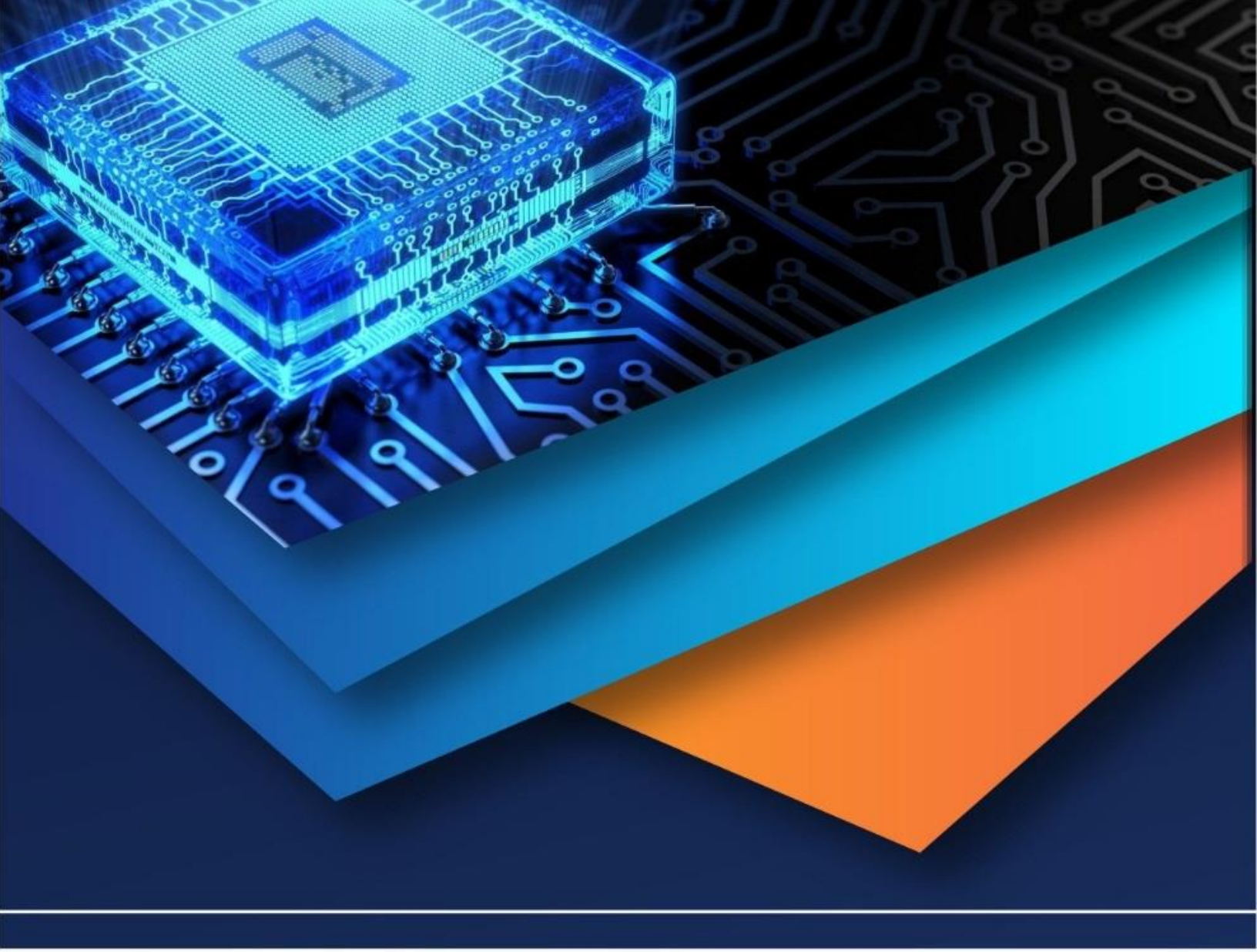
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