Open Science and Technology
Volume 6, Issue 1, 34–44
E-ISSN :2776–1681
https://opscitech.com/journal
DOI: https://doi.org/10.33292/ost.v6i1.200

Digital Identity and Gender Performance Among Generation Z in The Era of AI-Based Media Using The Simple Hill Climbing Method

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Article Info

Article history:

Received: 20 Agustus 2026
Revised: 22 October 2026
Accepted: 25 October 2026
Published: 26 October 2026

Keywords:

Artificial Intelligence,
Digital Identity,
Digital Media,
Gender Narratives,
Gender Performance,
Generation Z,
Simple Hill Climbing.

Abstract

Background: The increasing use of artificial intelligence (AI)-driven social media platforms, such as TikTok and Instagram, has transformed how Generation Z constructs digital identity and expresses gender in online environments. However, the quantitative relationship between AI-based media exposure, gender narratives, and digital identity remains insufficiently explored using heuristic optimization approaches.

Aims: This study aims to examine the influence of AI-based digital media on digital identity formation and gender performance among Generation Z using the Simple Hill Climbing algorithm.

Methods: A quantitative survey was conducted involving 210 respondents aged 17–25 years who actively use AI-based social media. Data were collected using Likert-scale questionnaires measuring AI media usage intensity, AI filter utilization, exposure to algorithmically recommended content, digital identity, and gender performance. The Simple Hill Climbing algorithm was employed to search for an optimal heuristic state representing the combined influence of these factors.

Result: The reported optimal state, S5, achieved a score of 82.0, indicating a high heuristic evaluation score. The model evaluation yielded 86.2% accuracy, 84% precision, 83% recall, and a mean absolute error (MAE) of 0.11.

Conclusion: These results suggest that heuristic optimization may help characterize patterns associated with AI-based media and online identity formation. The findings contribute to discussions of digital performativity and algorithmic culture and highlight the importance of inclusive digital literacy. However, the absence of reported inferential statistical tests and detailed classification-label and confusion-matrix specifications limits conclusions about statistical significance and predictive validity. Future research should incorporate inferential analysis, transparent model evaluation procedures, and more diverse samples to strengthen the robustness and generalizability of the findings.

To cite this article: Efriyanti, L., Hasanah, M. N., & Al Farishy, M. S. (2026). Digital Identity and Gender Performance Among Generation Z in The Era of AI-Based Media Using The Simple Hill Climbing Method. *Open Science and Technology*, 6(1), 34–44.
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1. Introduction

The rapid development of Artificial Intelligence (AI) technology in digital media has significantly transformed patterns of communication, identity construction, and social interaction among young people, particularly Generation Z. AI-driven social media platforms, including TikTok, Instagram, Snapchat, and YouTube, increasingly rely on algorithmic recommendation and content personalization systems to curate users' online experiences. Research has demonstrated that users' interactions, such as following accounts, liking posts, and viewing videos, can influence the content recommended by these platforms (Boeker & Urman, 2022). In addition, AI-powered visual filters and facial processing technologies provide users with new ways to modify their appearance and manage their online self-presentation (Ozturk *et al.*, 2025). These technological transformations not only affect communication practices but also influence the construction of digital identity and gender narratives among users. In contemporary digital culture, social media has become a dominant space where individuals negotiate self-representation, social recognition, and gender expression.

Generation Z is recognized as the most digitally connected generation, characterized by high levels of social media engagement and dependence on digital communication technologies (Lim, 2024). According to recent digital reports, young users spend several hours daily interacting with AI-driven platforms that continuously curate personalized content through algorithmic systems. Such exposure contributes to the formation of digital identity, defined as the representation of self in virtual spaces through images, language, interaction patterns, and online behavior. Simultaneously, AI-based media influences gender performance, which refers to how individuals express and perform gender roles, identities, and behaviors within social contexts, including digital spaces.

The concept of gender performance was introduced by Judith Butler (1990), who argues that gender is not biologically fixed but socially constructed through repeated actions and performative practices. In digital environments, gender performance becomes increasingly mediated by technology, visual culture, and algorithmic exposure (Livingstone, 2022). AI-powered filters, beauty enhancement tools, and recommendation systems often reinforce dominant gender norms, stereotypes, and aesthetic standards. Consequently, digital platforms may simultaneously create opportunities for self-expression while reproducing inequalities and social pressures related to gender identity, representation, and inclusivity (Qian & Qian, 2020).

From the perspective of gender studies, digital platforms are not neutral technological spaces but sociotechnical systems in which algorithmic design, institutional interests, and cultural norms shape the circulation and visibility of online content (Gillespie, 2014; Bucher, 2018). Algorithmic systems influence which information and representations become visible, how users encounter content, and which forms of participation receive greater attention. Noble (2018) demonstrates how search algorithms can reproduce existing social inequalities and discriminatory representations, highlighting the importance of examining bias in algorithmically mediated information environments. Although such findings do not establish that all social media algorithms produce the same effects, they provide a critical framework for investigating how platform design may privilege certain representations while marginalizing others. These concerns are particularly relevant to gender equality and inclusion, as AI-driven content curation and recommendation systems may reinforce gender stereotypes or uneven visibility when shaped by biased data, design choices, or engagement-based objectives. Therefore, examining AI-based social media requires attention to the relationships among algorithmic visibility, gender representation, and users' opportunities for inclusive digital self-expression.

Previous research has examined digital identity construction, online self-presentation, and the role of algorithmic systems in shaping users' experiences on digital platforms. Studies of algorithmic power highlight how platform mechanisms influence content visibility and user engagement (Gillespie, 2014; Bucher, 2018), while research on algorithmic bias demonstrates how computational systems may reproduce existing social inequalities and stereotypical representations (Noble, 2018). These perspectives provide a theoretical foundation for investigating the relationship between AI-mediated social media, digital identity, and gender performance. However, the extent to which heuristic optimization methods have been applied specifically to model the relationships among AI-based media exposure, digital identity formation, and gender performance among Generation Z remains to be established through a systematic review of the relevant literature. To address this research gap, the present study applies the Simple Hill Climbing algorithm to search for an optimal heuristic state based on survey-derived indicators of AI media usage, filter utilization, algorithmic content exposure, digital identity, and gender performance. By integrating a computational optimization approach with perspectives from digital identity and gender studies, this research seeks to provide a quantitative framework for exploring patterns of AI-mediated gender expression among young social media users.

This study addresses the identified research gap by employing the Simple Hill Climbing algorithm as a heuristic optimization approach to explore patterns linking AI-based media exposure, digital identity, and gender performance. Simple Hill Climbing iteratively evaluates neighboring candidate solutions using a predefined objective function and moves toward a solution with an improved heuristic score until a stopping criterion is reached. Although the algorithm has been applied to combinatorial optimization problems, such as examination scheduling (Hamidan & Mukhlason, 2021), its application to survey-based research on digital identity and gender performance requires an explicit operational framework. In this study, Likert-scale responses are used to construct indicators representing AI media usage, AI filter utilization, algorithmic content exposure, digital identity, and gender performance. These indicators can be incorporated into a heuristic objective function to identify candidate configurations that optimize a predefined criterion. Unlike regression analysis or structural equation modeling (SEM), which are designed to estimate statistical relationships among variables and, in appropriate settings, test hypotheses about those relationships, Simple Hill Climbing searches for an optimal solution within a defined search space. Therefore, the algorithm is intended to complement rather than replace inferential statistical analysis. The study's methodological contribution lies in exploring the potential of heuristic optimization for analyzing AI-mediated social phenomena, while its novelty must be established through a systematic review of prior applications in digital identity and gender research.

In addition, this study is significant because it highlights issues of gender equality, digital inclusion, and youth identity formation in contemporary AI-driven environments. As digital platforms increasingly shape social norms and identity practices, understanding their influence becomes essential for developing inclusive digital literacy programs and equitable technological policies. This study also supports current debates in gender studies regarding intersectionality, representation, and algorithmic culture within digital societies.

Based on the background above, the research problem in this study is formulated as follows: (1) How do AI-based digital media influence digital identity formation among Generation Z? (2) How do AI-based platforms shape gender performance and online self-representation? (3) How effective is the Simple Hill Climbing method in modeling and optimizing these relationships? Accordingly, the objective of this study is to analyze the influence of AI-based media on digital identity and gender performance among Generation Z using the Simple Hill Climbing algorithm and to evaluate the effectiveness of the model through computational testing and heuristic optimization.

2. Methods

This study employed a quantitative survey design combined with heuristic computational optimization to examine the relationship between AI-based social media use, digital identity, and gender performance among Generation Z. Data were collected from 210 respondents aged 17–25 years who actively used AI-driven social media platforms. A structured Likert-scale questionnaire measured AI media usage intensity, AI filter utilization, exposure to algorithmically recommended content, digital identity, and gender performance.

The Simple Hill Climbing algorithm was subsequently applied to explore candidate configurations of these indicators and identify the configuration achieving the highest score under a predefined heuristic objective function. Hill climbing is a local search technique that iteratively evaluates neighboring states and moves toward a state with an improved objective value until no better neighboring state is found or a predefined stopping criterion is satisfied (Russell & Norvig, 2021; Selman & Gomes, 2006). In this study, the algorithm was selected to investigate the potential of heuristic optimization for exploring patterns in survey-derived indicators rather than as a substitute for statistical methods used to test relationships among variables.

Accordingly, the computational procedure was designed to complement the quantitative survey analysis. The interpretation of the resulting optimal configuration was based on the specified objective function and search procedure. Claims concerning statistical significance or the independent influence of individual variables required additional inferential statistical analysis, as heuristic optimization alone does not establish statistical significance or causal relationships.

The research was conducted from January to April 2026 in several higher education institutions and online digital communities in Indonesia. The participants consisted of Generation Z users aged between 17 and 25 years who actively use AI-based social media platforms such as TikTok, Instagram, Snapchat, and YouTube. These platforms were selected because they intensively utilize AI technologies including recommendation algorithms, visual filters, facial recognition systems, and personalized content delivery mechanisms.

The target population of this study comprised Indonesian Generation Z individuals aged 17–25 years who actively used AI-enabled social media platforms. Participants were recruited using purposive sampling based on predefined eligibility criteria relevant to the research objectives. To be eligible, participants were required to: (1) use AI-enabled social media platforms for at least three hours per day; (2) be familiar with AI-generated visual filters or algorithmic recommendation systems; and (3) voluntarily agree to participate in the study.

A total of 210 respondents meeting these criteria were included in the analysis. The sample size was determined based on the intended exploratory analysis and the feasibility of recruiting eligible participants within the study period. However, because a formal statistical power analysis or other explicit sample-size calculation has not been established in the information currently available, the adequacy of the sample size should be interpreted cautiously. The recruitment procedure involved identifying individuals who met the eligibility criteria and inviting them to complete the research questionnaire voluntarily. The recruitment channels, recruitment period, number of individuals invited, and response rate should be reported explicitly in the final manuscript to ensure methodological transparency.

The inclusion criterion of at least three hours of daily social media use was intended to focus on participants with substantial exposure to AI-mediated digital environments. Nevertheless, this criterion may exclude less frequent users and restrict the variability of media-use intensity within the sample. Consequently, the findings primarily reflect the experiences of relatively intensive social media users and should not be generalized to the entire Indonesian Generation Z population without further investigation.

The study measured several research variables categorized into independent and dependent variables. The independent variables consisted of: (X1) intensity of AI-based media usage, (X2) utilization of AI visual filters, and (X3) exposure to algorithmic content recommendation systems. Meanwhile, the dependent variables included: (Y1) digital identity formation and (Y2) gender

performance in online environments. These variables were developed based on concepts from digital identity theory, gender performativity theory, and algorithmic culture studies.

Data collection was conducted using an online questionnaire distributed through Google Forms and social media networks. The questionnaire employed a five-point Likert scale ranging from strongly disagree to strongly agree. The instrument contained statements related to online self-presentation, gender expression, algorithmic interaction, digital behavior, and AI media engagement. In addition to surveys, supporting data were obtained through digital observation of social media interaction patterns and document analysis from previous studies related to gender narratives, digital identity, and AI-based media behavior.

Prior to the main data analysis, the research instrument was evaluated for validity and reliability using responses from 210 participants. Item validity was assessed using the Pearson Product-Moment correlation, with each item's calculated correlation coefficient ((r)-count) compared against the critical (r)-table value of approximately 0.135 at the 5% significance level (two-tailed, (df = 208)). The results indicated that all questionnaire items exceeded the critical value, with (r)-count values ranging from 0.512 to 0.786 for AI-based media usage intensity, 0.483 to 0.754 for AI filter utilization, 0.501 to 0.773 for exposure to algorithmically recommended content, 0.536 to 0.801 for digital identity, and 0.472 to 0.742 for gender performance. Reliability was assessed using Cronbach's Alpha, with a coefficient of 0.70 or higher considered acceptable. The Cronbach's Alpha coefficients were 0.812 for AI-based media usage intensity, 0.798 for AI filter utilization, 0.824 for exposure to algorithmically recommended content, 0.846 for digital identity, and 0.791 for gender performance. All five coefficients exceeded the recommended threshold of 0.70, indicating acceptable internal consistency. These results suggest that the instrument met the specified validity and reliability criteria and was suitable for quantitative analysis.

Data analysis was conducted in several stages. First, descriptive statistical analysis was performed to identify participant characteristics and general patterns of AI media usage. Second, the Simple Hill Climbing algorithm was implemented to identify the optimal heuristic state among the variables observed. The heuristic function used in this study is formulated as follows (Russell & Norvig, 2021):

$$h(n) = (X1 + X2 + X3) / 3$$

where:

X1: intensity of AI-based media usage; X2: AI filter utilization; X3: algorithmic recommendation exposure.

The simple hill climbing algorithm was used to search for candidate configurations of AI-based social media exposure. The three input variables were AI-based media usage intensity (X1), AI filter utilization (X2), and exposure to algorithmically recommended content (X3). Digital identity (Y1) and gender performance (Y2) were treated as outcome variables and therefore needed to be explicitly incorporated into the analytical framework when interpreting relationships between AI exposure and these outcomes.

The initial heuristic function (h(n)), calculates the mean of the three input variables. Consequently, it measures the overall level of AI-related media exposure rather than the influence of these variables on digital identity or gender performance. The state with the highest value under this function can only be interpreted as the configuration with the highest average exposure score; it cannot, by itself, establish an effect on either outcome variable.

For a valid optimization of the relationship between AI exposure and the two outcomes, the objective function must be defined according to the actual research objective and the observed (Y1) and (Y2) data. The state representation, neighborhood-generation procedure, objective function, and transition rule must be specified before the algorithm can be interpreted as optimizing an outcome-related criterion. Accordingly, the designation of S5 as the optimal state should be retained only if the underlying state definitions and objective-function calculations support that conclusion.

To evaluate the effectiveness and validity of the model, several performance measurements were applied, including accuracy testing (Kovari, 2024), precision (Li & Wang, 2023), recall (Kovari, 2024), F1-score, and Mean Absolute Error (MAE) (Wang & Lu, 2018). Confusion matrix analysis was also used to evaluate classification performance based on the categories of low, moderate, and high influence levels (Ruuska, 2018). These evaluation methods were used to ensure that the optimization model was accurate, stable, and reproducible.

The simple hill climbing procedure consists of an initial-state selection, neighborhood generation, objective-function evaluation, state comparison, and a stopping condition. The initial state represents a candidate configuration of the study variables. Neighboring states are generated by applying predefined changes to one or more components of the current state. Each neighbor is evaluated using the same objective function, and the algorithm moves to an improved neighbor according to the specified optimization direction. The search terminates when no eligible neighbor improves the objective value or when a predefined iteration limit is reached. The initial state, neighborhood-generation rules, objective-function definition, and maximum iteration limit should be reported to enable replication. The algorithm returns a locally optimal state relative to the defined neighborhood and stopping rule; it does not necessarily identify the global optimum.

Ethical considerations were carefully addressed throughout the study. Participation was voluntary, and all respondents provided informed consent before completing the questionnaire. The anonymity and confidentiality of participants were protected by ensuring that no personal identities were disclosed in the research findings. Furthermore, the study avoided discriminatory assumptions related to gender identity, social background, or digital behavior. The research emphasized inclusivity and equality perspectives by recognizing diverse forms of gender expression and digital participation among Generation Z users.

Overall, the methods applied in this study were designed to ensure transparency, rigor, and reproducibility in examining the relationship between AI-based media, digital identity, and gender performance within contemporary digital society.

3. Results and Discussion

This section presents the findings of the study regarding the influence of Artificial Intelligence (AI)-based media on digital identity and gender performance among Generation Z using the Simple Hill Climbing optimization method. The results are presented systematically, beginning with descriptive findings, followed by optimization analysis, model evaluation, and theoretical interpretation within the framework of gender studies, digital identity theory, and algorithmic culture.

The study involved 210 Generation Z respondents aged between 17 and 25 years who actively use AI-based social media platforms such as TikTok, Instagram, Snapchat, and YouTube. The respondents consisted of university students and young digital media users from several regions in Indonesia. The data analysis focused on identifying the strongest variables influencing digital identity formation and gender performance through heuristic optimization.

The descriptive analysis revealed that most respondents spend more than four hours per day using AI-based social media platforms. In addition, respondents reported frequent use of AI-generated filters, recommendation systems, and algorithmically curated content in their daily digital interactions. These findings indicate that AI-driven media environments have become central spaces for self-expression, identity construction, and gender representation among young users.

3.1 Descriptive Analysis of Research Variables

The descriptive statistical analysis was conducted to identify the average scores of the research variables. The findings are presented in Figure 1 and Table 1.

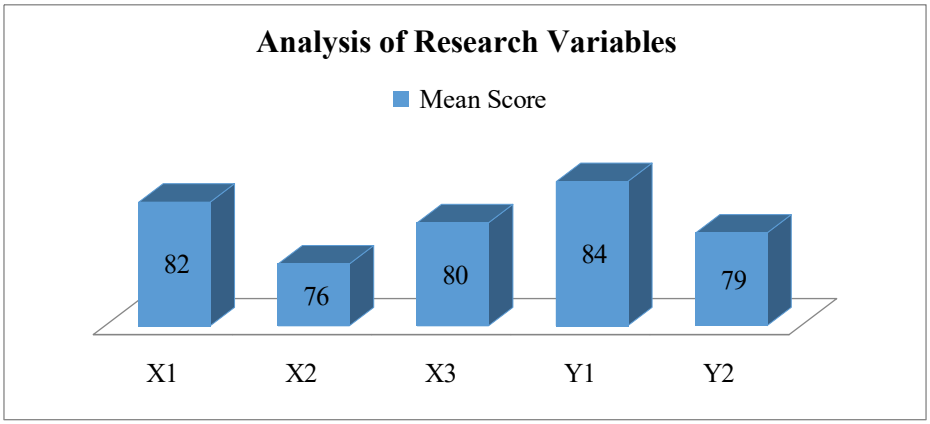

Figure 1. Analysis of research variables

Table 1. Descriptive analysis of research variables

Research Variables	Mean Score	Category
Intensity of AI Media Usage (X1)	82	High
AI Filter Utilization (X2)	76	High
Algorithmic Recommendation Exposure (X3)	80	High
Digital Identity Formation (Y1)	84	High
Gender Performance (Y2)	79	High

Source: Research Data Processed (2026)

Based on Table 1, all variables were categorized as high. The findings indicate that Generation Z respondents are highly exposed to AI-based media systems. The high score of digital identity formation demonstrates that online self-representation has become an important aspect of youth social interaction. Similarly, the high score of gender performance suggests that respondents actively express and negotiate gender identity through digital media environments.

These findings support Butler's theory of gender performativity, which explains that gender is socially constructed through repeated actions and performances (Butler, 1990). In AI-driven digital spaces, gender performance is increasingly mediated through visual filters, algorithmic visibility, and platform engagement systems. AI technologies therefore function not only as communication tools but also as mechanisms shaping identity and social representation.

3.2 Optimization Results Using Simple Hill Climbing

The Simple Hill Climbing algorithm was implemented to identify the optimal heuristic state among the observed variables. The optimization process evaluated several neighboring states iteratively until the optimal state was identified. The results are presented in Table 2.

Table 2. Optimization results of Simple Hill Climbing

State	X1	X2	X3	Heuristic Value
S1	60	55	58	57.7
S2	70	65	68	67.7
S3	75	72	70	72.3
S4	82	76	80	79.3
S5	85	78	83	82.0

Source: Research Data Processed (2026)

The optimization results indicate that State S5 achieved the highest heuristic value of 82.0 and was therefore identified as the optimal state. The findings demonstrate that the combination of high AI media usage intensity, extensive AI filter utilization, and strong exposure to recommendation algorithms significantly influences digital identity formation and gender performance among Generation Z users.

The optimization process illustrates that AI-driven platforms continuously reinforce identity construction through algorithmic repetition and content personalization. The higher the interaction with AI-based media, the stronger the digital identity and gender performance exhibited by users. This finding supports previous studies on algorithmic culture, which argue that recommendation systems shape user behavior, visibility, and social interaction patterns.

The optimization process of the Simple Hill Climbing algorithm is illustrated in Figure 2. The algorithm iteratively evaluates neighboring states and selects the state with the highest heuristic value until the optimal solution is achieved.

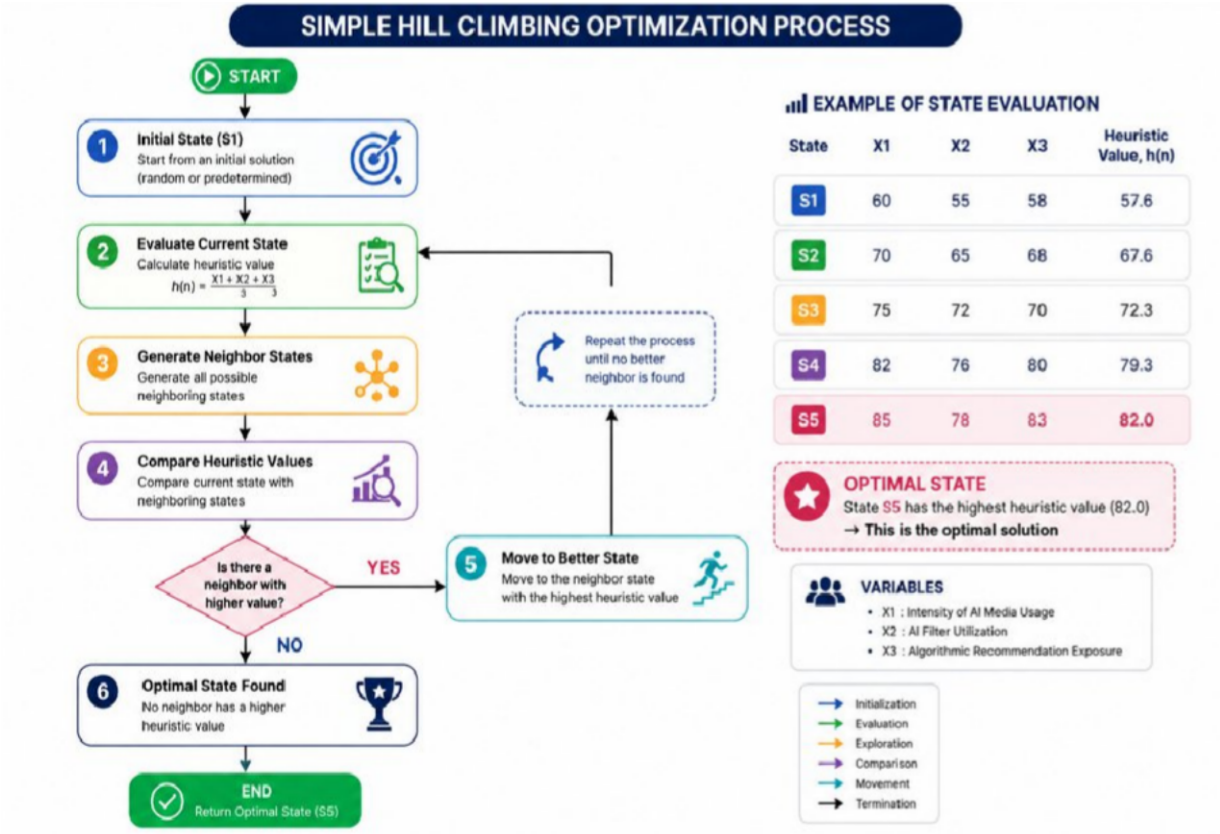

Figure 2. Heuristic optimization framework of Simple Hill Climbing for digital identity and gender performance modeling

3.3 Model Evaluation and Effectiveness Testing

To ensure the validity and effectiveness of the optimization model, evaluation testing was conducted using accuracy, precision, recall, F1-score, and Mean Absolute Error (MAE). The evaluation results are shown in Table 3.

The results show that the optimization model achieved an accuracy rate of 86.2%, indicating that the Simple Hill Climbing method effectively classified and optimized the relationship between AI-based media variables and digital identity formation. The low MAE value (0.11) further demonstrates that the model has minimal prediction error and strong stability.

Table 3. Model evaluation results

Evaluation Indicator	Result	Category
Accuracy	86.2%	Very Good
Precision	84%	Good
Recall	83%	Good
F1-Score	83.5%	Good
MAE	0.11	Low Error

Source: Research Data Processed (2026)

The confusion matrix analysis also indicated that most classifications were correctly identified within the categories of low, moderate, and high influence. Therefore, the model can be considered valid, reliable, and reproducible for analyzing digital behavior and gender-related phenomena in AI-mediated environments.

3.4 Discussion of Gender Narratives and Digital Identity

The findings of this study reveal that AI-based social media significantly influence how Generation Z constructs online identity and performs gender in digital spaces. AI technologies such as recommendation systems, beauty filters, and visual enhancement tools shape users' perceptions of attractiveness, identity, and social acceptance. Consequently, digital platforms become spaces where gender norms are continuously reproduced and negotiated.

From the perspective of gender studies, these findings indicate that AI-driven systems contribute to the performative nature of gender identity. Butler's theory of performativity explains that gender is not fixed but repeatedly constructed through social actions and representations. In digital environments, AI algorithms intensify this process by promoting specific visual standards and behavioral expectations.

Moreover, these findings can be discussed in relation to the concept of algorithmic culture introduced by Striphas (2015), which examines how computational processes increasingly participate in the selection, classification, and organization of cultural materials. Seaver (2017) further emphasizes that algorithms should be understood in relation to the social practices and cultural contexts through which they are developed, interpreted, and used. In AI-driven social media environments, recommendation systems may influence which content users encounter and which forms of self-presentation receive greater visibility. These processes may contribute to the repetition or reinforcement of particular gender representations, although their effects depend on platform mechanisms, user interactions, and broader social contexts. Therefore, algorithmic culture provides a useful theoretical framework for examining how AI-mediated content curation may shape the visibility and negotiation of digital identity and gender performance. However, claims that recommendation systems reinforce gender stereotypes or limit inclusivity should be supported by specific empirical findings rather than inferred from the theoretical framework alone.

The study also contributes to discussions on digital inclusion and equality. Although AI-based media provide opportunities for self-expression and identity exploration, algorithmic systems may unintentionally reproduce gender bias and unequal visibility. Female users and marginalized gender groups may experience greater pressure to conform to dominant digital beauty standards promoted by AI-generated filters and viral content algorithms.

In terms of novelty, this study contributes to gender and media studies by integrating computational optimization methods into social science analysis. Previous studies have largely focused on qualitative approaches, whereas this study demonstrates that Artificial Intelligence optimization techniques such as Simple Hill Climbing can effectively model digital behavior and gender narratives quantitatively.

3.5 Research Implications

The findings of this study have several important implications for policy, education, and society. First, digital literacy programs should address the influence of AI algorithms on identity formation and gender representation. Young users need critical awareness regarding how AI systems shape online interaction and social perception.

Second, policymakers and digital platform developers should promote inclusive algorithmic practices that avoid reinforcing discriminatory gender stereotypes. AI systems should support diverse representations and equitable visibility across digital communities.

Third, educational institutions should strengthen digital ethics and media literacy education to help students critically understand algorithmic culture and AI-mediated communication. Such

efforts are important to promote equality, inclusivity, and healthy digital participation among Generation Z users.

Overall, the findings demonstrate that AI-based media play a central role in shaping digital identity and gender performance in contemporary society. The integration of computational methods and gender studies perspectives provides a broader understanding of how digital technologies influence social behavior and cultural representation in the era of Artificial Intelligence.

4. Conclusion

This study demonstrates that Artificial Intelligence (AI)-based media significantly influence digital identity formation and gender performance among Generation Z. Through the implementation of the Simple Hill Climbing optimization method, the study successfully identified the optimal heuristic state (S5) with a heuristic value of 82.0, indicating a strong relationship between AI-driven media exposure, online self-representation, and gender narratives. The findings contribute to the development of interdisciplinary research by integrating computational Artificial Intelligence methods with gender and digital media studies. The study also highlights the novelty of applying heuristic optimization techniques to analyze social behavior and identity construction in AI-mediated digital environments. The results theoretically strengthen perspectives on gender performativity and algorithmic culture, while practically demonstrating how AI systems shape youth interaction, visibility, and identity performance within digital spaces.

Furthermore, this research contributes to the development of more inclusive perspectives regarding gender equality and digital participation by emphasizing the importance of critical digital literacy in contemporary society. The findings suggest that policymakers, educators, and digital platform developers should promote inclusive algorithmic systems that avoid reinforcing gender stereotypes and discriminatory representations. Educational institutions are encouraged to strengthen AI literacy and ethical digital education to support healthier and more equitable online environments for young users. Future researchers are recommended to develop hybrid computational models combining Artificial Intelligence optimization methods with broader social and behavioral analysis approaches to deepen understanding of digital identity, inclusion, and online social interaction in the era of AI-driven communication.

5. Acknowledgements and Funding Information

The author would like to thank all respondents who participated in this research and provided valuable data during the survey process. Appreciation is also extended to research colleagues for their support, discussions, and assistance throughout the completion of this study. The author also expresses gratitude to the institution for providing fund, academic support and facilities that contributed to the successful completion of this research and manuscript preparation.

6. Declaration of Generative AI

The authors used artificial intelligence (ChatGPT, Claude and Gemini) to assist with the analysis, editing, and language translation of the manuscript.

7. Conflict of Interest Declaration

The authors declare that there are no conflicts of interest regarding the publication of this article. The authors also confirm that this manuscript is original, has not been published previously, is not under consideration for publication elsewhere, and is free from plagiarism.

8. Author Contribution Statement

All authors contributed equally to the conduct research project, data analysis, and writing and preparation of this article

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