# SURVEY ON STUDYMATE PLATFORM FOR STUDENTS USING GALE SHAPLEY ALGORITHM

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**ABSTRACT**

*Matching entities based on preferences and constraints is a fundamental challenge across diverse domains, including education, online marketplaces, healthcare, resource allocation, and secure communications. Traditional or simplistic approaches often prove inadequate, leading to instability, inefficiency, bias, or neglect of crucial stakeholder preferences. This compilation of research explores the development, application, and evaluation of advanced matching algorithms, with a prominent focus on the Gale-Shapley stable matching algorithm and its variants. Studies investigate adaptations for various contexts (e.g., one-to-many, single-list inputs, incorporating utility theory, AI-driven metrics, security requirements) and compare their performance against benchmarks like first-come-first-serve, random assignment, or other algorithms (e.g., K-Means). Results consistently demonstrate that principled matching algorithms, especially those guaranteeing stability like Gale-Shapley, significantly improve outcomes such as social welfare, user satisfaction, fairness, resource utilization, and system robustness, despite inherent complexities and context-specific trade-offs. These approaches provide robust frameworks for optimizing real-world allocation and pairing problems.*

**Keywords:** *Matching Algorithms, Gale-Shapley Algorithm, Stable Matching, Utility Theory, Preference Matching, Resource Allocation, System Design, Algorithm Comparison, Online Platforms, Educational Technology.*

## 1. INTRODUCTION

The problem of efficiently and fairly matching individuals, resources, or services arises ubiquitously in numerous modern systems, ranging from student admissions and course enrollment [18, 23] to online dating [9], healthcare facility allocation [23], peer-to-peer sharing platforms [14], resource management in ports [13], decentralized 3D printing [4, 24], and secure device communication [20]. Simple allocation mechanisms like first-come-first-serve or manual assignment often fail to account for the complex preferences and constraints of all involved parties, leading to suboptimal outcomes, instability, and dissatisfaction [4, 7]. There is a pressing need for structured, algorithm-driven approaches that can navigate these complexities.

The Gale-Shapley algorithm, renowned for guaranteeing stable matches in two-sided markets [15, 24], serves as a central theoretical foundation for many advanced matching systems explored herein. Stability, ensuring no pair of agents mutually prefers each other over their assigned partners, is critical for preventing strategic manipulation and ensuring system integrity [5, 8]. However, applying and extending these principles to diverse real-world scenarios necessitates significant adaptation and integration with other methodologies. The presented body of work investigates various applications and modifications of Gale-Shapley and related matching concepts, incorporating techniques like utility theory for preference modeling [4, 24], AI and machine learning for prediction and optimization [1, 3, 13, 19, 21], game theory for strategic analysis [5, 10, 14, 22], specific domain constraints (e.g., cognitive skills [6], personality traits [11], security requirements [2, 20]), and innovative explanation methods like Shapley values [12]. These studies develop and evaluate frameworks for one-to-one, many-to-one, and many-to-many matching, aiming to enhance efficiency, fairness, user satisfaction, and overall system performance, often through rigorous comparison with baseline or alternative algorithms [7, 10, 22].

## 2. MILESTONES

The article titled “The Effect of Applying Active Learning Model Type Index Card Match on Students’ Higher Order Thinking Skills (HOTS)” authored by Efni Cerya and Yulia Fitra was published in 2023. This quasi-experimental study investigated the impact of the index card match active learning model on the Higher Order Thinking Skills (HOTS) of Class XI Social Sciences students compared to a conventional model. Using a non-equivalent control group design and Two-Way ANOVA analysis, the results showed that students using the index card match model had significantly higher HOTS. High learning activity also correlated positively with HOTS. However, no interaction effect between the learning model and learning activity level was observed, indicating they influence HOTS independently.

The article titled “Identity-Based Matchmaking Encryption, Revisited Improved Constructions with Strong Security” authored by Sohto Chiku, Keitaro Hashimoto, Keisuke Hara, and Junji Shikata was published in 2024 (preprint/report date). This work revisits identity-based matchmaking encryption (IB-ME), refining security definitions and proposing enhanced constructions. It categorizes existing privacy and authenticity notions, introduces mismatch security, and presents two efficient IB-ME schemes. The first, based on BDH in the ROM, achieves stronger CCA-privacy and CMA-authenticity with compact keys/ciphertexts. The second provides an improved generic construction from IBE, IBS, and reusable extractors in the standard model, offering stronger security and the shortest ciphertexts among generic constructions, suitable for various cryptographic assumptions including lattices.

The article titled “Effects of Player-Level Matchmaking Methods in a Live Citizen Science Game” authored by Alexander D. Stoneman, Josh Aaron Miller, and Seth Cooper was published in 2022. This study explored player-level matchmaking (dynamic difficulty adjustment using player/level ratings) in the live citizen science game Foldit. An experiment involving 221 players compared logistic DWR, fixed DWR, random, and linear level ordering. Matchmaking methods (logistic, fixed DWR) resulted in significantly more levels completed and higher peak levels than random ordering, but not significantly better than a static linear (increasing difficulty) order. The results suggest player-level matchmaking has potential in live CSGs but may be most effective when combined with other dynamic difficulty adjustment approaches.

The thesis titled “A DECENTRALIZED 3D PRINTING SERVICE FRAMEWORK BASED ON GALE-SHAPLEY MATCHING” authored by Naman Mandhan was completed in 2016.

Addressing the underutilization of 3D printers and the limitations of first-come-first-serve matching in decentralized service portals, this work proposes a framework using the Gale-Shapley algorithm. By applying utility theory to capture bilateral preferences of designers (service seekers) and machine owners (service providers), the framework aims to improve matching efficiency and social welfare. Evaluation indicated that the Gale-Shapley approach yielded higher total social welfare compared to the FCFS method. Despite slight biases, both parties achieved improved utility and better matches, demonstrating the potential for practical implementation via a web-based platform.

The article titled "A Potential Application of Gale-Shapley Stable Marriage Model in the Babysitter-Households Matching in China" authored by Luyin Wang was published in 2021. Motivated by the increased demand for babysitters in China, this paper suggests an online recruitment system (ORSB) leveraging the Gale-Shapley Stable Marriage model. It proposes a two-sided matching mechanism between households and babysitters based on bilateral preferences using a Deferred-Acceptance algorithm. The paper details the system's operation, discusses its ideal characteristics (thickness, stability, strategy-proofness, Pareto optimality), and examines its potential benefits for individuals (reliable matching, career support) and the macroeconomy (increased labor supply, higher birth rates to address aging). Limitations regarding preference elicitation and real-world complexities are also noted.

The article titled ""E-Matching Card" to Improve Cooperation and Cognitive Abilities Among Nursing Students" authored by Elsye Maria Rosa, Sri Sundari, Eny Retna Ambarwati, Galuh Suryandari, Erna Rochmawati, and Farid Suryanto was published in 2023. This study developed and assessed an "E-Matching Card" game, based on the cooperative 'make a match' strategy, to enhance nursing students' cognitive skills and cooperation. A pretest-posttest control group design involving 60 fourth-semester nursing students compared the E-Matching Card intervention with a standard cooperative learning approach. Findings showed that the game-based method significantly improved students' understanding, interprofessional communication, and collaboration (p=0.000), while reducing stress compared to the control group. The study concludes that the E-Matching Card game is an effective tool for improving nursing students' knowledge and teamwork skills.

The article titled "Algorithm Comparison for Student-Supervisor Matching in Supervisorship System Development: K-Means vs. One-to-Many Gale-Shapley" authored by Azamat Serek and Meirambek Zhaparov was published in 2023. This paper compares K-Means clustering and the One-to-Many Gale-Shapley algorithm for matching students to supervisors based on multiple criteria including preference satisfaction and workload balance. Experimental results demonstrated Gale-Shapley's superior performance, yielding significantly better preference satisfaction (0.74 vs 0.34) and workload balance (0.5 vs 0.2) compared to K-Means. Gale-Shapley also provided a more equitable workload distribution (max/min: 6/3 vs 15/3) with comparable efficiency. Gale-Shapley is recommended for achieving better quality matches and balance, despite its implementation complexity.

The article titled "Asymmetry of strategies in proposal: Gale-Shapley algorithm on diagrams" authored by Yoshiteru Ishida and Shigetaka Ikeno was published in 2016. This paper introduces novel diagrams, inspired by railway diagrams, to visualize the process and strategic aspects of the stable marriage problem (SMP) solved by the Gale-Shapley algorithm. These diagrams depict blocking relations and highlight asymmetries in the algorithm's proposal actions. By assuming global preference knowledge, the diagrams allow a decision-maker or individual agents to deduce strategies based on agent popularity and preference structures. The study focuses on how these visual

representations can reveal process knowledge and strategic implications, potentially informing game-theoretic models or educational applications.

The article titled “A Gale-Shapley View of Unique Stable Marriages” authored by Kartik Gokhale, Amit Kumar Mallik, Ankit Kumar Misra, and Swaprava Nath was published in 2024. This paper examines unique stable matching (USM) conditions through the lens of the Gale-Shapley Deferred Acceptance (DA) algorithm. It introduces two new sufficient conditions, MaxProp (maximum proposals) and MaxRou (maximum rounds), based on the algorithm's execution metrics. MaxProp is shown to imply MaxRou (for $n \geq 3$), and both are sufficient for USM. A characterization of MaxProp allows efficient verification without running DA. For $n \geq 3$, MaxProp is demonstrated to be disjoint from prior conditions like SPC and NCC, thus identifying new structures within the USM class. The distinct structure for $n=2$ is also analyzed.

The article titled “Implementation of Stable Pairing Algorithms for Optimizing Educational Games: A Computational and Pedagogical Perspective” authored by Luiz Carlos Pinheiro Junior, Everton Gomede, and Leonardo de Souza Mendes was published in 2024. This study modifies the Gale-Shapley algorithm to pair students in educational digital games using a single participant list and compatibility scores derived from Jaccard similarity (based on proficiency/performance data). It compares this modified algorithm with random pairing. Results demonstrate that the modified Gale-Shapley approach forms pairs with superior compatibility, consistency, and balance. The findings suggest integrating stable pairing algorithms, adapted for educational contexts, into digital learning tools can significantly enhance collaboration, competition, and student engagement by creating more effective and stable peer pairings.

The article titled “Therapy matchmaking: Patient-therapist match in personality traits and attachment style” authored by Rivka Shir and Orya Tishby was published in 2024. This research explored the relationship between patient-therapist similarity on personality (Big Five) and attachment styles and outcome in short-term dynamic therapy. Using data from 77 dyads, response surface analysis revealed that symptom reduction was greater when patient-therapist pairs matched on neuroticism (both high or both low) and conscientiousness (both high or both low). Conversely, matching on attachment anxiety (both high or both low) was linked to increased symptoms. The study suggests that pre-therapy matching on specific traits contributes significantly to outcome, highlighting the potential utility of considering these factors in therapist referrals.

The article titled “Shapley Values for Explanation in Two-sided Matching Applications” authored by Suraj Shetiya, Ian P. Swift, Abolfazl Asudeh, and Gautam Das was published in 2024. This paper proposes using Shapley values to explain outcomes in large-scale two-sided matching systems where recommendations are top-k lists based on attribute ranking functions. Addressing the competitive nature of ranking, the framework explains various user queries (e.g., match presence/absence, list composition) by quantifying the contribution of each attribute. Due to the complexity of exact computation, a sampling-based approximation algorithm with provable guarantees is introduced. Experiments on real/synthetic data and a user study validate the usefulness and efficiency of Shapley values for providing transparency in complex matching scenarios, outperforming baseline methods.

The article titled “Contemporary challenges and AI solutions in port operations: applying Gale–Shapley algorithm to find best matches” authored by Mehran Farzadmehr, Valentin Carlan, and Thierry Vanelslander was published in 2023. This study tackles the problem of matching appropriate AI solutions to challenges in port operations. It first identifies port challenges and reviews relevant AI solutions. A modified Gale–Shapley algorithm, run from both challenge and solution perspectives, is used to find the best matches based on developer and literature-derived preferences. A heuristic weighting method reconciles results from the two phases. The findings show Machine Learning, particularly Reinforcement Learning, addresses key challenges. The study highlights AI's potential for optimizing port operations and suggests the matching framework aids stakeholders in selecting suitable, often reusable, AI solutions.

The article titled “First vs. Lasting Impressions: How Cognitive and Affective Trust Cues Coordinate Match-Making in Online Sharing Platforms” authored by Timm Teubner, David Dann, Florian Hawlitschek, and Mareike Möhlmann was published in 2024. This research investigates the dynamic effects of cognitive (star ratings) and affective (profile photos) trust cues on trusting behavior in online peer-to-peer sharing platforms. A multi-period laboratory experiment using an adapted trust game with endogenous matching found that affective cues (photos) have a strong initial positive effect that follows an inverted U-shape, diminishing over time. Cognitive cues (ratings) have a weaker initial effect but steadily increase in influence. The cues act complementarily, with affective cues crucial early on and cognitive cues gaining importance later, suggesting dynamic interplay in trust formation.

The article titled “Optimizing Social and Emotional Learning through Modified Gale-Shapley Algorithm for Collaborative and Competitive Education” authored by Luiz Carlos Pinheiro Junior, Everton Gomede, and Leonardo de Souza Mendes was published in 2024. This paper proposes a modified Gale-Shapley algorithm to optimize student pairings in educational settings fostering Social and Emotional Learning (SEL) through collaborative and competitive activities. The algorithm operates on a single list of students, using objective compatibility metrics (Inverse Euclidean, Jaccard, Cosine similarity) instead of traditional preference lists. Simulations using synthetic datasets of varying sizes demonstrate the algorithm's efficiency and scalability in creating stable, compatible pairs, thereby enhancing learning experiences. The approach offers a robust, personalized framework aligning with SEL goals, though empirical validation in real classrooms is suggested for future work.

The article titled “Predictive Factors for Surgical Decision Making in Nonconcussive Traumatic Brain Injury Patients without Immediate Surgery: A Propensity Score Matching Study of Optic Nerve Sheath Diameter, Glasgow Coma Scale, and Rotterdam Computed Tomography Score” authored by Chayanin Wanachiwanawin et al. was published in 2025. This retrospective study assessed predictors of subsequent surgery in 251 nonconcussive Traumatic Brain Injury (TBI) patients who didn't undergo immediate surgery. Using propensity score matching, 27 surgical patients were compared to 224 non-surgical patients. Multivariable analysis revealed initial Glasgow Coma Scale (GCS) scores of 9-12 (OR 5.596) and Rotterdam CT scores >3 (OR 5.024) were significant predictors of needing surgery within 48 hours. Initial CT-derived optic nerve sheath diameter (ONSD) was not predictive. The study concludes initial GCS and Rotterdam scores, but not ONSD, help anticipate delayed surgery needs in this patient group.

The article titled “STUDENTS’ READING COMPREHENSION IN LEGEND BY USING MAKE A MATCH” authored by Khairunnisah, Happy Sri Rezeki Purba, and Rezzi Angriani Lubis was published in 2022. This Classroom Action Research aimed to improve Grade VIII students' reading comprehension of narrative legends using the Make

a Match strategy via WhatsApp e-class. The study involved 30 students over two cycles. Pre-test results showed low comprehension (13.33% pass rate). After Cycle I, the pass rate improved to 53.33%. Following revisions to address difficulties and improve engagement in Cycle II, the mean score increased significantly, and the pass rate reached 90%. The study concludes that the Make a Match strategy, even in an e-learning context, effectively improves students' reading comprehension skills for narrative texts.

The article titled “Playing with Matches: Adopting Gale–Shapley for Managing Student Enrollments Beyond CS2” authored by Anna N. Rafferty et al. was published in 2024. Addressing enrollment pressures in Computer Science, this paper describes "the Match," a course reservation system based on the Gale–Shapley algorithm, implemented at Carleton College for post-CS2 courses. The system aims to increase access, encourage broader course selection, and meet student needs equitably, avoiding issues of competitive enrollment. Data from three years show high student participation, effective preference matching (>90%), increased enrollment by younger students, and reduced simultaneous course taking ("bingeing"). While waitlists increased, the Match appears to decrease student/faculty angst and manage enrollment consistent with liberal arts values, without disproportionately harming underrepresented groups.

The article titled “Waste-to-Energy Online Marketplace: Leveraging AI Recommendation Matchmaking for Enhanced Biomass Sourcing in Bioenergy Production” authored by
Kanjanapon Borisoot et al. was published in 2024. This paper introduces a Waste-To-Energy
Online Marketplace platform designed to facilitate the exchange of biomass feedstock, particularly post-harvest sugarcane leaves, for bioenergy production. The platform uses an AI recommendation engine for matchmaking between biomass suppliers (farmer groups) and bioenergy facilities (sugar factories), considering factors like location, quantity, type, and pricing. The goal is to optimize the biomass supply chain, promote efficient resource utilization, reduce waste burning emissions, and foster collaboration towards a sustainable energy future. The system operates via website and LINE mobile application, streamlining trading processes.

The article titled “Enhancing Security and Privacy in 5G Device-to-Device Communication: A
Secure Gale-Shapley Algorithm Approach” authored by Musaad Alruwaili, Junghwan Kim, and Jared Oluoch was published in 2025. This paper proposes a comprehensive security framework for 5G Device-to-Device (D2D) communication. It integrates AI-enhanced physical layer key generation, full-duplex adaptive jamming, secure multi-party computation (MPC), lightweight encryption, and differential privacy within a refined Gale-Shapley resource allocation algorithm. This holistic approach aims to protect against eavesdropping, MitM attacks, and privacy breaches while maintaining low latency and high throughput suitable for IoT environments. MATLAB simulations demonstrate the framework's effectiveness and resilience against various threats, confirming its suitability for securing mission-critical D2D communication compared to solutions focusing on isolated security aspects.

The article titled “Negative-Aware Attention Framework for Image-Text Matching” authored by Kun Zhang, Zhendong Mao, Quan Wang, and Yongdong Zhang was published in 2022 (likely CVPR). Addressing the false-positive problem in image-text matching caused by overlooking mismatched fragments, this paper proposes a Negative-Aware Attention Framework (NAAF). Unlike prior methods focusing mainly on matched fragments, NAAF explicitly models both positive effects (matched fragments) and negative effects (mismatched fragments). It features: 1) discriminative mismatch mining via iterative optimization to maximally separate similarity distributions and learn

an adaptive boundary, and 2) a two-branch matching mechanism (negative/positive attention) to precisely calculate dissimilarity/similarity. Experiments on Flickr30K and MSCOCO show NAAF significantly outperforms state-of-the-art methods.

The article titled "Gale-Shapley Matching Game Selection—A Framework for User Satisfaction" authored by Menatalla Abououf, Shakti Singh, Hadi Otrok, Rabeb Mizouni, and Anis Ouali was published in 2019. This paper proposes a framework (GSMS) using the Gale–Shapley matching game to allocate multiple workers to multiple tasks in mobile crowd sensing (MCS), prioritizing worker satisfaction alongside task requirements (QoS, completion confidence). It adapts the one-to-many college admissions problem to a many-to-many matching scenario based on worker and task preferences. Simulations using a real-life dataset show GSMS significantly outperforms a benchmark greedy-genetic algorithm (GGA-I) in terms of task confidence, QoS, and worker satisfaction, while maintaining comparable worker travel distance, demonstrating a scalable and effective approach for user-centric task allocation.

The article titled "Application of Gale-Shapley algorithm in optimal matching for healthcare facilities to elderly population: the case of Hangzhou, China" authored by Lepeng Huang, Kexun Zhang, Yiqiao Sun, Guoqiang Shen & David Coursey was published in 2024. This study is the first empirical application of the Gale-Shapley algorithm to match healthcare facilities with elderly populations in residential neighbourhoods in Hangzhou, China. Considering facility attributes (level) and population preferences (level, distance), the research demonstrates that this bilateral stable matching approach optimizes pairings similarly to Pareto optimality and is superior to unilateral spatial or non-spatial utility matching. It combines advantages of both distance-based and level-based preferences. The study also provides a conceptual model classifying urban healthcare spaces, concluding the algorithm yields optimal, stable matches improving overall healthcare access utility.

The article titled "MATCHING DESIGNERS AND 3D PRINTING SERVICE PROVIDERS USING GALE-SHAPLEY ALGORITHM" authored by Naman Mandhan, Joseph Thekinen, Alan Lo, and Jitesh H. Panchal was published in 2016. This paper addresses matching in decentralized 3D printing marketplaces where designers seek services from machine owners. It critiques the common first-come-first-serve approach for underutilizing machine capacity and ignoring owner preferences. The authors propose using the Gale-Shapley algorithm, incorporating utility theory to capture bilateral designer and machine owner preferences. Comparative analysis shows the Gale-Shapley method improves total social welfare over FCFS. While slightly biased depending on the proposing side, the algorithm provides improved utility for both parties and matches them to higher-ranked options, demonstrating its effectiveness for this application.

## 3. CONCLUSION

The diverse range of applications explored underscores the critical role of effective matching algorithms in optimizing resource allocation, service provision, and social interactions across many domains. Simplistic or ad-hoc methods frequently fall short, failing to ensure stability, efficiency, or fairness, particularly when dealing with complex preferences and constraints. The collective findings presented strongly indicate that structured matching algorithms, with the Gale-Shapley algorithm and its underlying principles of stability serving as a prominent example, offer significant advantages. Implementations and adaptations consistently demonstrate improvements in user satisfaction, preference fulfillment, workload balancing, social welfare, and system robustness compared to baseline approaches.

Integrating these algorithms with complementary techniques such as utility theory, AI/ML, and game theory allows for sophisticated modeling of real-world complexities, from student-supervisor compatibility [7] and patient-therapist dynamics [11] to trust in online platforms [14] and secure resource allocation [20]. However, challenges remain, including the need for accurate preference elicitation, computational scalability for very large datasets, ensuring fairness beyond just stability [9], and bridging the gap between theoretical models and practical implementation complexities [13, 18]. Future work should continue to focus on empirical validation in dynamic, real-world settings, developing more scalable and adaptable algorithms, enhancing explainability [12], and addressing the ethical implications of algorithmic matching. Ultimately, principled, algorithm-driven matching frameworks are indispensable tools for designing more efficient, equitable, and effective systems.

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*Note: The reference numbers [#] inserted in the Introduction and Conclusion are illustrative placeholders pointing to the source paper numbers from the list provided in the previous turn. In a final paper, these would correspond to the actual entries in your bibliography.*

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