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Beyond the Anti-Gaming Narrative: An Association Rule Mining Analysis of Problematic Gaming and Academic Performance among Undergraduate Students

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Abstract

Problematic gaming has become a pressing issue in higher education, often linked to student well-being and academic performance. This study applies association rule mining (ARM) to explore the complex relationships between gaming behaviours, demographic factors, and educational outcomes among undergraduates. A seven-item Game Addiction Scale (GAS-7) questionnaire was administered to a total of 324 (Male 107; Female 217) with mean age and standard deviation 20.96±0.98 and their responses were recorded. The Apriori algorithm was employed with a minimum support of 0.08 and confidence of 0.5 to identify high-lift network connected with behavioural addiction and academic performance. Eight key rules emerged, challenging conventional assumptions about academic decline. Notably, problem gaming showed a strong positive association with high academic achievement among first-year students living off campus (lift = 1.806, confidence = 0.833). A gendered technological divide was also evident: male students were more closely linked to computer-based problem gaming (lift = 1.376), while mobile gaming correlated with non-problematic use across genders. Campus residence consistently appeared protective, aligning with controlled, non-pathological gaming habits. These findings highlight the need for universities to move beyond generic anti-gaming narratives and adopt targeted, platform-specific wellness strategies. Interventions should focus on high-achieving first-year students and those in unsupervised off-campus housing, addressing the environmental and academic pressures that drive intensive gaming. These approaches can promote balanced digital engagement while safeguarding both academic success and psychological health.

Keywords: Academic performance; association rule mining; game addiction scale; Malaysian undergraduate students; problematic gaming

Introduction

The rapid growth of digital gaming has transformed leisure activities worldwide, with over 2.7 billion active gamers globally, representing nearly one-third of the population (Clement, 2021). While gaming can enhance cognitive skills such as attention, problem-solving, and decision-making (Bavelier & Green, 2019; Smith & Basak, 2023), excessive use has been associated with negative outcomes, including reduced academic performance and impaired well-being (Ferguson, 2015). In higher education, where students face significant academic and social pressures, gaming behaviours can either serve as a coping mechanism for stress or evolve into problematic patterns that disrupt learning and personal development (Raouf et al., 2022).

Recent systematic reviews highlight the mixed evidence regarding the relationship between problematic gaming and academic achievement (Männikkö et al., 2020). While earlier studies suggested a strong negative correlation, more recent findings indicate that poor academic performance may actually precede

and contribute to problematic gaming rather than being its direct consequence (Alzahrani & Griffiths, 2025). This evolving perspective accentuates the need for methodological approaches that move beyond simple correlations to uncover the socio-educational contexts in which gaming behaviours occur.

Association rule mining (ARM) offers a promising avenue for such exploration. By identifying frequent patterns and relationships within large datasets, ARM has been successfully applied to behavioural research, including studies of gaming behaviour and personality traits (Gao et al., 2023; Musa et al., 2025). Despite growing recognition of gaming's dual role as both a potential enhancer and inhibitor of student success, higher education institutions often adopt generalized anti-gaming narratives that overlook contextual factors such as academic standing, residence status, and platform-specific use. This gap in understanding limits the development of effective interventions. Consequently, the present study aims to address this problem by applying association rule mining to identify socio-demographic and educational profiles associated with problematic gaming among Malaysian undergraduates. Specifically, they sought to achieve the following objectives:

1. To examine the relationships between gaming behaviours, demographic factors, and academic outcomes using ARM.
2. To identify high-lift association rules that reveal intricate profiles of problem gamers.
3. To provide evidence-based insights that can inform targeted, platform-specific wellness strategies in higher education.

By integrating behavioural data with advanced analytical techniques, this study seeks to move beyond simplistic assumptions of academic decline and instead highlight the complex interplay between gaming, achievement, and student well-being.

Literature Review

Epidemiological and clinical research consistently identifies specific demographic and psychological vulnerabilities that predispose individuals to problematic gaming. Gender and age are primary predictors; males and younger adolescents frequently exhibit significantly higher rates of problematic gaming than their female or older counterparts (Jaafar et al., 2021). Among clinically referred children and youth, externalizing symptoms (such as proactive and reactive aggression) and extreme shyness serve as robust predictors for gaming addiction in males, whereas internalizing symptoms, most notably anhedonia, or the inability to feel pleasure, are predictive across both genders (Lau et al., 2018).

Psychological distress encompassing depression, anxiety, and perceived stress forms a strong, bidirectional relationship with gaming addiction (Yen et al., 2019). Excessive gaming frequently functions as an avoidance coping mechanism, providing psychological escape from real-world stressors (Rajab et al., 2020). However, this negative escapism paradoxically exacerbates social isolation, leading to a cyclical pattern where heightened distress drives further gaming (Sinha et al., 2024). In some instances, however, high internet usage during periods of extreme global stress, such as the COVID-19 lockdowns, served as a protective factor against anxiety for certain student populations by maintaining virtual social connections (Ismail et al., 2021).

A central focus of contemporary research is the impact of gaming addiction on educational outcomes, though the literature presents a highly debated narrative. A substantial portion of empirical studies highlights a direct negative association between problematic gaming and academic performance (Masud et al., 2016). Structural equation modelling demonstrates that gaming addiction negatively impacts Grade Point Averages (GPAs), driven largely by maladaptive behaviours such as academic procrastination, school avoidance, poor time management, and sleep deprivation (Shukry et al., 2024; Zameri et al., 2024). The addictive nature of games pulls students' attention away from their responsibilities, leading to delayed assignments, isolation, and diminished scholarly productivity (Zameri et al., 2024).

Conversely, other studies report no significant direct association between gaming addiction and academic performance, or suggest that the negative impact of video games on academic subjects may be too minor to be genuinely problematic (Yildiz Durak et al., 2022). To reconcile these mixed findings, a comprehensive systematic review of 27 studies revealed a crucial temporal shift in the data: while older research (pre-2015) overwhelmingly positioned gaming addiction as a predictor of poor academic outcomes, recent longitudinal studies increasingly demonstrate a reciprocal or reverse relationship(Alzahrani & Griffiths,

2025). Based on the compensatory use model, recent evidence suggests that poor academic performance acts as a primary catalyst for problematic gaming; students facing academic distress and lower grades retreat into virtual environments to compensate for their real-world failures and fulfil their need for success (Alzahrani & Griffiths, 2025). Furthermore, a student's underlying contingencies of self-worth, such as appearance, competition, and academic competency, interact heavily with their preferred game genres to either increase or decrease addiction risks (Yildiz Durak et al., 2022).

Materials and Method

Before the start of the study, students were briefed on its objectives, and verbal consent was obtained during the initial data collection sessions through their respective course coordinators. Ethical approval for the research was granted by the Departmental Ethics Committee of Universiti Malaysia Terengganu (UMT/PPAL/530-32 JILID). All participants provided informed consent before taking part. Importantly, the study was conducted anonymously, ensuring that no personal information about the students was collected or disclosed. The following procedures were then implemented to achieve the research objectives.

Participants

This study adopted a descriptive cross-sectional survey design, utilizing a stratified sampling method to capture representation across academic levels, gender, and fields of study. The final sample, calculated using G*Power analysis, consisted of 324 undergraduate students aged 18 to 25 years (mean age = 20.96, SD = 0.98). Of these, 107 were male and 217 were female. Participants were drawn from first- to sixth-year cohorts enrolled in diverse programs across six public universities in Malaysia.

In terms of ethnicity, the majority of respondents were Malay (78.8%). Chinese students accounted for 10.4%, while Indian students represented 7.1% of the sample. The remaining 4% comprised students from various indigenous groups, particularly from East Malaysia (Sabah and Sarawak), including Iban, Kadazan, Dusun, and Bajau communities. All participants voluntarily took part in the study.

Data Acquisition and Transformation

In this study, the validated seven-item Game Addiction Scale (GAS-7), which has demonstrated strong psychometric properties across diverse populations (Khazaal et al., 2016; Lau et al., 2018), was used as the main instrument for data collection.

Data pre-processing was carried out using the Pandas library in Python to ensure both structural consistency and validity for subsequent analyses. Raw questionnaire responses were first standardized by mapping items to uniform variable names. Demographic categories, particularly gender and ethnicity, were cleaned through string normalization and consolidation of equivalent entries.

Self-reported time-use data (e.g., gaming, sleep, and exercise durations) were provided in varied formats. To address this heterogeneity, a parsing algorithm was applied to convert textual and numeric inputs, including minutes, fractions, and ranges, into a consistent decimal-hour format. This transformation was essential for comparability in behavioural research (Cohen et al., 2013).

Responses to the GAS-7 were converted from ordinal Likert ratings (1 = Never to 5 = Very Often) into numerical values. Missing data within the scale were imputed using median substitution, a method recognized for preserving sample size while maintaining the central tendency of Likert-type distributions (Downey & King, 1998).

Finally, composite psychometric measures were derived following the framework of Lemmens et al. (2011). These included a total score ranging from 7 to 35, as well as two binary classifications: problem gaming (defined polythetically as scoring ≥ 3 on at least four items) and addicted gaming (defined monothetically as scoring ≥ 3 on all seven items) as recommended by the preceding investigators (Lemmens et al., 2009, 2011). The resulting dataset was optimized for robust inferential statistical testing.

Development of the Rule Mining Model

Association rule learning is a data mining method designed to uncover meaningful relationships among variables within a dataset. In commercial applications, this approach is often referred to as market basket analysis, where it is used to identify purchasing patterns among customers. The concept was first introduced by the preceding investigators and has since been widely applied across diverse research domains (Agrawal et al., 1998).

For this study, the Apriori algorithm was employed to generate association rules. This algorithm evaluates relationships using three key measures namely support, confidence, and lift to determine the strength and relevance of correlations. Minimum thresholds for support and confidence were set at values of 1 or higher to filter out weak or non-informative patterns.

Survey responses were preprocessed to address missing data and ensure overall quality before rule generation. The Apriori algorithm was then applied to identify associations between variables, with particular emphasis on factors linked to problematic gaming behaviour. To maintain clarity and interpretability, the model was restricted to producing rules with no more than three items in the antecedent and consequent, thereby avoiding overly complex or difficult-to-interpret outputs.

Performance Evaluation Metrics

Support refers to the proportion of transactions in which a particular itemset appears. A higher support value indicates that the itemset occurs frequently within the dataset, reflecting its overall prevalence. Confidence measures the conditional probability that a transaction containing item A also includes item B. Elevated confidence values suggest a stronger likelihood that item B is present when item A occurs, thereby reflecting the reliability of the rule. Lift evaluates the strength of an association by comparing the observed support to the expected support under independence. A lift greater than 1 indicates a positive association, meaning the presence of item A increases the probability of item B. A lift equal to 1 suggests independence, while values below 1 imply a negative association. To enhance interpretability, redundant rules such as those that were subsets of broader rules were removed, ensuring that only the most informative associations were retained. Rule validity was further assessed using a holdout validation strategy, where the dataset was divided into training (70%) and testing (30%) subsets. Rules generated from the training set were then evaluated on the testing set to confirm their generalizability.

Findings

Figure 1 depicts the comparative analysis of the associated rules with respect to the evaluated metrics. The figure compares Support, Confidence, and Lift across the identified association rules, showing that while Support values for the most significant behavioural rules remain relatively low (concentrated around 0.10 to 0.15), Confidence is generally high (ranging from 0.40 to 0.98) and Lift consistently reaches up to 1.75, indicating strong positive associations. It could be observed from the Figure that the rule representing problem gaming among male students with Second Upper CGPAs stands out with the highest Lift (~1.75), making it the strongest and most insightful association in the dataset. In contrast, rules clustered at the high end of the Support scale (exceeding 0.80) such as the link between Year One students and on-campus housing have higher Support but lower Lift (approaching 1.0), indicating they are common but offer less predictive novelty. Overall, the chart highlights the trade-off between frequency (Support), reliability (Confidence), and the strength of the relationship (Lift) in evaluating the factors contributing to student gaming habits.

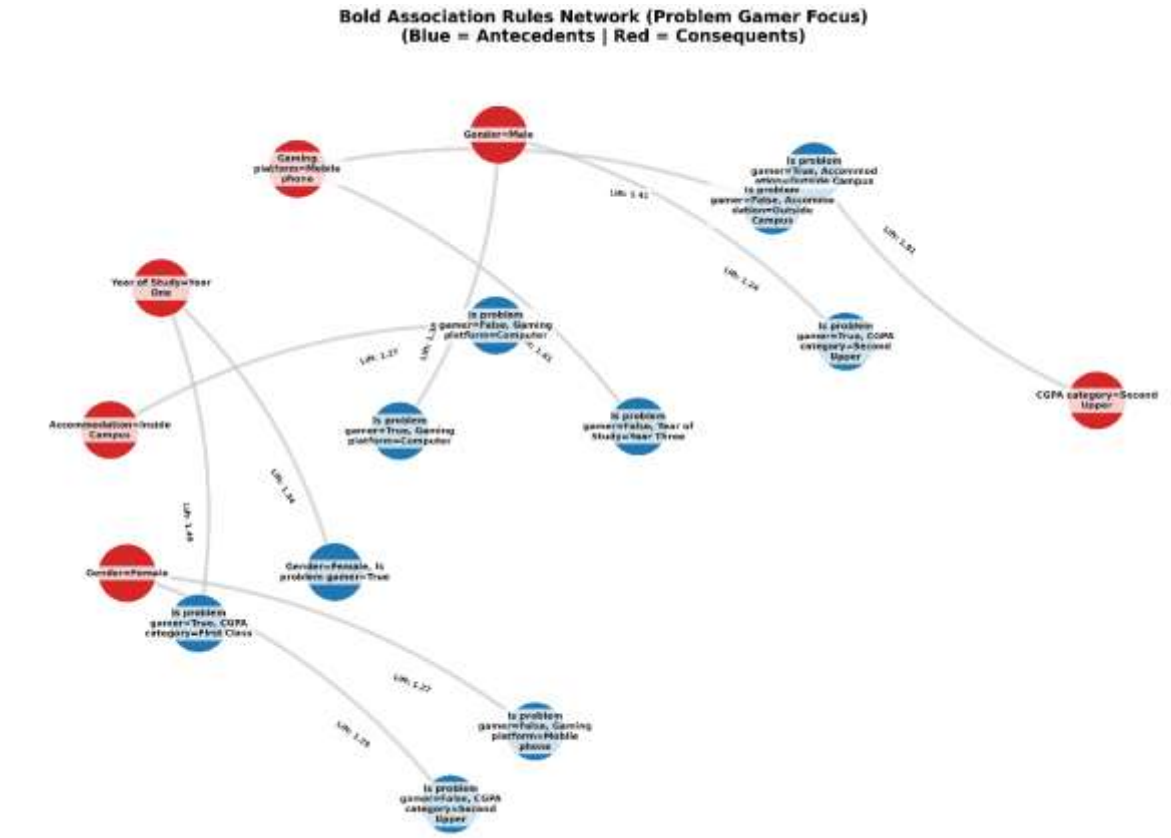

Figure 1. Associated rules network for the study parameters.

Figure 2 depicts the comparative analysis of the associated rules with respect to the evaluated metrics. The figure compares Support, Confidence, and Lift across eight association rules, showing that while Support values remain relatively low, Confidence is generally high and Lift consistently exceeds 1, indicating positive associations. Rule R1 stands out with the highest Lift (1.81), making it the strongest and most insightful association, whereas rules like R7 have higher Support but weaker predictive power. Overall, the chart highlights the trade-off between frequency, reliability, and novelty in evaluating association rules.

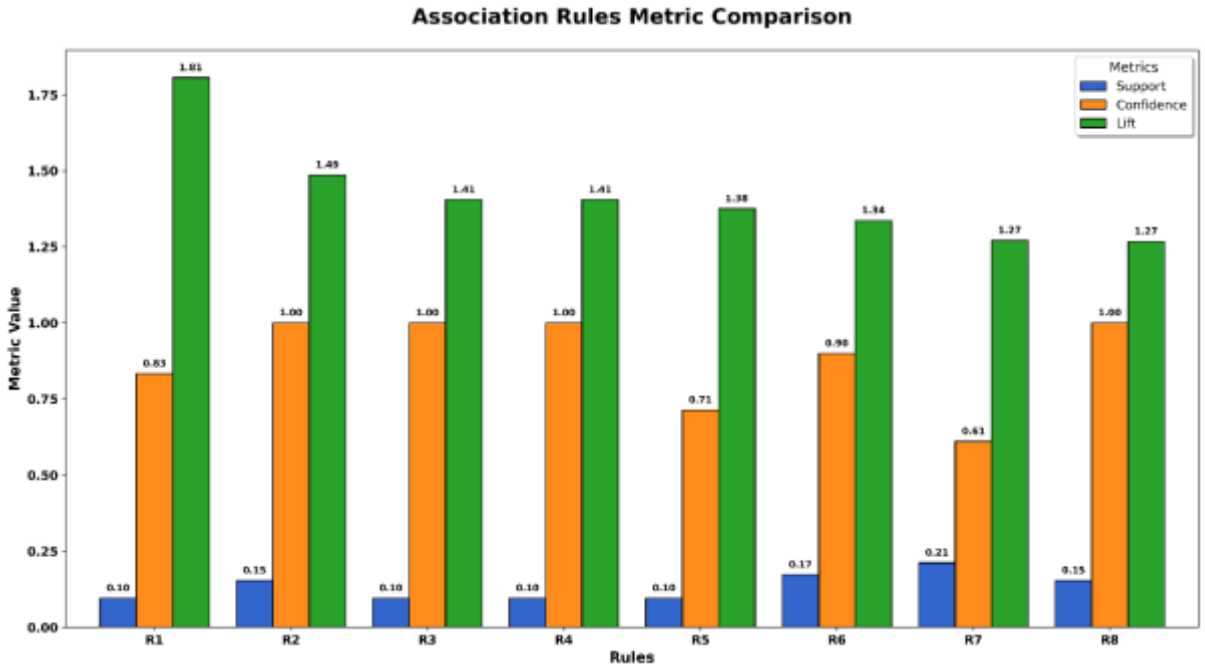

Figure 2. Comparison of Association rules metrics for the generated network.

Determinants of problematic gaming tendencies and its association of student's characteristics are depicted in Table 1. Rule 1 shows that the association between problem gamers living outside campus and Second Upper CGPA categories has a relatively low support (0.096) but high confidence (0.833) and a lift of 1.806. The lift significantly greater than 1 suggests a strong positive association, indicating that problem gamers living off-campus are nearly twice as likely to fall into the Second Upper academic category than expected by chance. Similarly, Rule 2 demonstrates that the association between problem gamers with a First Class CGPA and being in their Year One of study has moderate support (0.154), perfect confidence (1.0), and a lift of 1.486, indicating a positive correlation between early-stage high achievers and problem gaming traits.

The association between non-problem gamers living outside campus and the use of mobile phones for gaming (Rule 3) shows moderate support, perfect confidence, and a lift of 1.41. This suggests that mobile gaming is a predominant platform for students who do not exhibit problem gaming behaviours. Similarly, Rule 4 demonstrates an identical association for Year Three students who are non-problem gamers, suggesting that as students' progress to their third year, those without gaming issues remain positively associated with mobile platforms.

The table further shows the rule-driven data from Rule 5, which reveals the association between problem gamers using computers and the male gender. With a lift of 1.376 and moderate confidence (0.714), this indicates a positive association between male students and computer-based problem gaming. Rule 6 shows that female students who are problem gamers are strongly associated with being in Year One, with high confidence (0.9) and a lift of 1.337, suggesting that gaming issues among females may be more prevalent at the start of their academic journey.

Finally, Rules 7 and 8 focus on non-problem gamers. Rule 7 shows that female non-problem gamers are positively associated with mobile gaming (lift of 1.271). Rule 8 shows that non-problem gamers using computers are strongly associated with living on campus (confidence of 1.0 and lift of 1.268), suggesting that the campus residential environment, combined with computer use, may be more characteristic of controlled, non-problematic gaming habits.

Table 1. Market basket analysis of mental gaming tendencies among undergraduate students

Rules	Antecedents	Consequents	Support	Confidence	Lift
1	Is PG =True, Accommodation=Outside Campus	CGPA C=Second Upper	0.096	0.833	1.806
2	Is PG =True, CGPA C =First Class	Year of Study=Year One	0.154	1	1.486
3	Is PG =False, Accommodation=Outside Campus	GP =Mobile phone	0.096	1	1.405
4	Is PG =False, Year of Study=Year Three	GP =Mobile phone	0.096	1	1.405
5	Is PG =True, GP =Computer	Gender=Male	0.096	0.714	1.376
6	Gender=Female, Is PG=True	Year of Study=Year One	0.173	0.9	1.337
7	Is PG =False, GP=Mobile phone	Gender=Female	0.212	0.611	1.271
8	Is PG =False, GP =Computer	Accommodation=Inside Campus	0.154	1	1.268

Note: Is PG = Is problem gamer, CGPA C = CGPA category, GP = Gaming platform

Discussion

The findings indicate a paradoxical relationship between problem gaming and academic achievement, challenging the traditional displacement hypothesis which suggests that excessive gaming necessarily leads to academic decline. Instead, the strong association between problem gaming and high-tier CGPA categories (First Class and Second Upper) among first-year students suggests that high-achieving students may utilize intensive gaming as a high-stimulation coping mechanism for academic stress. This aligns with research by Király et al. (2017), which posits that for some highly functional individuals, gaming serves as a primary stress-regulation tool during high-pressure transitions (Király et al., 2017). The prevalence of these rules in Year One further suggests that the initial transition to the university environment is a critical period where gaming habits coalesce with academic identities, necessitating early intervention strategies that focus on high-achievers who may be masking behavioural issues behind academic success.

Furthermore, the data highlights a significant socio-spatial dimension to gaming behaviours, particularly concerning residential status. The positive association between off-campus living and problem gaming among Second Upper students suggests that the relative lack of institutional supervision and the "digital cocooning" effect of private accommodation may foster more intensive gaming habits. Conversely, the association of on-campus residency with non-problematic computer use supports the findings of Saunders et al. (2017), who noted that structured campus environments and proximity to peer-regulated study spaces can act as protective factors against the development of disordered gaming (Saunders et al., 2017). This suggests that the physical environment and the degree of social integration within the university housing system are influential mediators of gaming intensity.

Finally, the gendered nature of platform preference remains a defining characteristic of the gaming landscape. The positive association between male students and computer-based problem gaming, contrasted with the mobile-centric habits of non-problematic female gamers, reinforces the "technology-gender gap" identified by (Lopez-Fernandez et al., 2019). While mobile platforms are often integrated into the "micro-breaks" of daily life, computer gaming frequently involves longer, more immersive sessions that are more susceptible to becoming problematic. These findings suggest that university wellness programs should adopt a platform-specific approach, recognizing that while mobile gaming is ubiquitous and generally non-pathological, computer-based gaming among male students in private accommodation represents a high-risk profile for behavioural addiction.

Conclusion and Recommendations

The findings of this study reveal that problematic gaming among undergraduates is not a monolithic predictor of academic failure but rather a complex behavioural trait frequently intersecting with high academic achievement and specific environmental stressors. While the strong association between problem gaming and top-tier CGPA categories suggests that gaming may serve as a high-stimulation coping mechanism for high-achieving students, the protective influence of on-campus residency highlights the role of structured environments in mitigating behavioural addiction. Consequently, it is recommended that university administrators and student wellness centres pivot from generic anti-gaming campaigns toward targeted, platform-aware interventions that prioritize first-year students and off-campus residents. By integrating digital wellness literacy into academic counselling, particularly for high-performing students who may be masking gaming disorders, institutions can develop a more proactive support system that preserves academic excellence while safeguarding the psychological health of the student.

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Availability of data and materials: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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