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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 participants (Male 107; Female 217) with a mean age and standard deviation of 20.96±0.98 years, 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 associations connected with behavioural addiction and academic performance. The analysis revealed several significant association rules, indicating problematic gaming. 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: problematic gaming, Malaysian undergraduate students, academic performance, association rule mining, game addiction scale

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). Existing literature shows that a range of demographic and psychological factors influence problematic gaming. Gender and age have consistently been identified as key predictors, with males and younger individuals showing higher susceptibility (Jaafar et al., 2021).

Psychological distress, including depression, anxiety, and stress, is also strongly associated with problematic gaming, often functioning as both a cause and consequence of excessive engagement (Yen et al., 2019; Rajab et al., 2020). While gaming may temporarily relieve real-world stressors, prolonged use can intensify social isolation and reinforce maladaptive behavioural cycles (Sinha et al., 2024). The relationship between problematic gaming and academic performance remains highly debated. Earlier studies reported a direct negative association, linking gaming addiction with lower academic achievement and behaviours such as procrastination, poor time management, and sleep disruption (Masud et al., 2016; Shukry et al., 2024; Zameri et al., 2024). However, more recent research suggests a more complex and potentially reciprocal relationship, where poor academic performance may precede and contribute to problematic gaming (Alzahrani & Griffiths, 2025). This evolving perspective indicates the need for analytical approaches that move beyond simple correlations to better understand the contextual and behavioural dynamics underlying gaming practices.

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 examine the relationships between gaming behaviours, demographic characteristics, and academic outcomes among Malaysian undergraduates, with the aim of identifying high-lift behavioural patterns and generating evidence-based insights to support 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.

Materials and Method

Prior to 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 years). 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 collection and pre-processing

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. These values were converted into a consistent decimal-hour format using a parsing algorithm, enabling comparability across responses (Cohen et al., 2013). GAS-7 responses were transformed from ordinal Likert-scale ratings (1 = Never to 5 = Very Often) into numerical values. Missing data were handled using median imputation to preserve sample size and maintain distributional stability (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.

Data Analysis

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 pre-processed 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.

Results

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 can 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 figure 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.

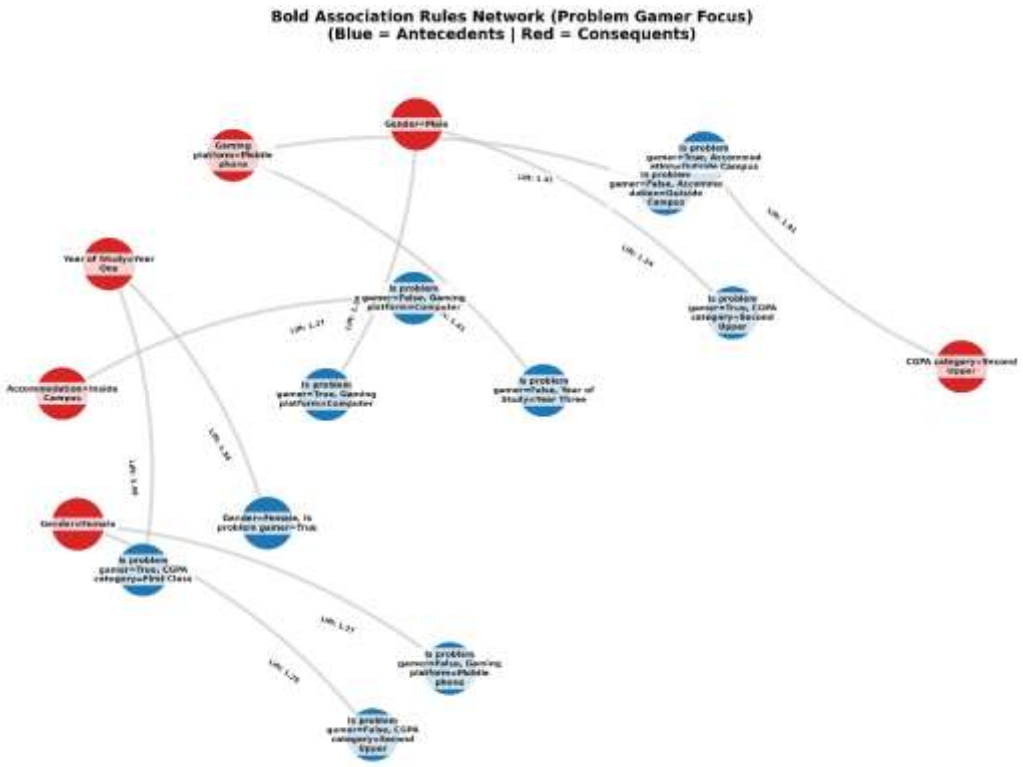


Figure 1. *Associated Rules Network for the Study Parameters*

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.

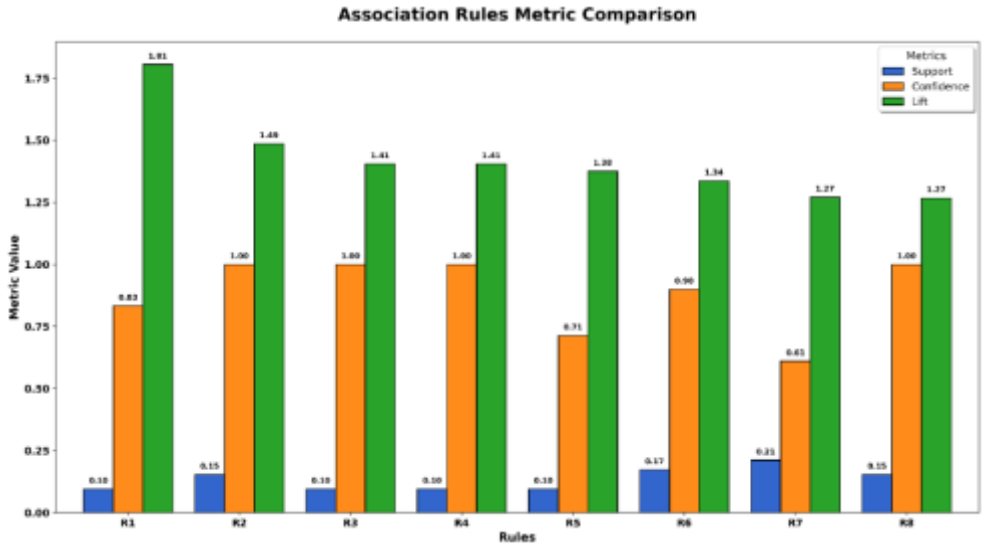


Figure 2. *Comparison of Association Rules Metrics for the Generated Network*

Table 1 depicts the determinants of problematic gaming tendencies and their association with students' characteristics. 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 outcome 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 highlights the role of gaming in stress regulation among highly functional individuals. Alternatively, it is also possible that students with strong academic abilities are better able to manage both gaming and academic responsibilities simultaneously, rather than gaming contributing positively to performance.

The prominence of these patterns among first-year students further suggests that the transition into university life may play a significant role, although this cannot be definitively established within the current cross-sectional design. Other unmeasured factors, such as prior academic ability, personality traits, or time-management skills, may also explain these associations. Therefore, while the findings highlight an important trend, they should not be interpreted as evidence that problematic gaming enhances academic success. The results also indicate a potential socio-spatial dimension to gaming behaviours (Saunders et al., 2017). The association between off-campus living and problem gaming may reflect reduced supervision

and increased autonomy in private environments. Nevertheless, this relationship may also be influenced by confounding variables such as socioeconomic status, access to personal devices, or differing lifestyle patterns between on-campus and off-campus students. In contrast, on-campus residency appears to be associated with more controlled gaming behaviours, possibly due to structured environments and peer interaction. However, further research is needed to confirm whether residence status directly influences gaming behaviour or merely reflects broader contextual differences.

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.

Overall, the current study provides evidence of context-dependent associations between gaming behaviour and academic outcomes. Future research should employ longitudinal designs and incorporate additional psychological and environmental variables to better understand the directionality and underlying mechanisms of these relationships. Such approaches would support the development of more targeted and evidence-based interventions in the context of higher education.

Conclusion

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. The key contribution of this study lies in applying association rule mining to uncover hidden behavioural patterns that are not easily captured through traditional correlation-based approaches. 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 students' psychological health.

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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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