

Article

Between Addiction and Immersion: A Correlational Study of Digital and Academic Behaviour Among Engineering Students

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Abstract

In the age of digital transformation, where students increasingly rely on technology for learning and communication, concerns arise regarding its potential association with academic outcomes. This study quantifies the relationship between Digital Behaviour (DB) and Academic Behaviour (AB) among engineering undergraduates at Misurata, Al-Asmarya Islamic, and Al-Marqab universities in Libya. DB is conceptualised as a spectrum ranging from excessive, compulsive device use (addictive behaviour) to purposeful academic technology use (digital immersion). Using a descriptive-analytical design, a convenience sample of 300 undergraduate engineering students completed a validated 20-item questionnaire (Cronbach's $\alpha = 0.711\text{--}0.899$ for subscales). Data were analysed using descriptive statistics, Pearson correlation, simple regression, and analysis of variance (ANOVA) in the Statistical Package for the Social Sciences (SPSS) v23. The analysis identified a weak but statistically significant positive correlation between students' DB and their AB ($r = +0.19$, $p = 0.002$). Notably, AB scores increased in the senior study years, while digital engagement remained consistently high across all years, suggesting an evolving capacity among students to regulate their digital habits. ANOVA results revealed significant differences in AB by year of study, while gender showed no significant overall association. These findings contradict the conventional assumption that heavy digital use uniformly diminishes academic outcomes; instead, in digitally immersed learning environments, strategic DB may coexist with or support academic performance. The study concludes that DB is not inherently detrimental to AB and may provide benefits when managed effectively, especially among more advanced engineering students. It recommends early educational interventions that promote digital self-regulation and the strategic use of technology for academic purposes.

Keywords: digital addiction; digital behaviour; academic behaviour; engineering education; digital immersion



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1. Introduction

Over the past two decades, the global higher education landscape has been reshaped by an unprecedented digital transformation (Dahl & Bergmark, 2020; Wu & Yuan, 2023; X. Yuan et al., 2024). Digital technologies have become deeply integrated into students' academic and social lives, enabling new possibilities for learning, research, and communication. In engineering education, the use of simulation software, online collaboration platforms, and

digital libraries has become central to knowledge acquisition and project execution (Wu & Yuan, 2023; Moses, 2023). However, this increasing reliance on technology raises a critical concern: how do students navigate the fine line between productive digital engagement and deleterious overuse, commonly referred to as digital addiction?

Digital addiction involves compulsive behaviours such as persistent social media engagement, prolonged online gaming, and difficulty disconnecting from digital devices (Billieux et al., 2015). These behaviours have been associated with negative academic outcomes, including impaired attention spans, disrupted time management skills, and difficulties in emotional regulation—all vital for successful academic behaviour (AB) (Small et al., 2020). Empirical evidence demonstrates correlations between excessive digital use and poorer academic indicators, such as decreased Grade Point Average (GPA), lower levels of academic engagement, and increased anxiety and burnout (Sunday et al., 2021; Gu et al., 2023). A systematic review has further highlighted that excessive social media use co-occurs with reduced mental well-being, exacerbating anxiety, stress, and sleep disturbances (Liu et al., 2024). Additionally, students with inadequate time-management skills appear particularly susceptible to digital overuse cycles (Y. Yuan et al., 2023). Consequently, interventions promoting digital detox strategies have been recommended to address these observed associations (Radtke et al., 2022).

Nevertheless, the relationship between students' Digital Behaviour (DB) and AB is not one-dimensional. Academic achievement increasingly correlates with students' ability to strike a balance between effective technology use and disciplined study practices Wu and Yuan (2023). In this sense, DB exists on a continuum from addiction to immersion. Digital immersion, when intentional and well-managed, may correlate with enhanced AB by providing rapid access to information, fostering peer collaboration, and supporting flexible learning environments (Alaleeli & Alnajjar, 2020). This dual nature of digital engagement necessitates a re-evaluation of the assumption that increased digital use inevitably leads to academic decline.

Digital immersion, a concept situated at the intersection of digital pedagogy and human–computer interaction, refers to a mental state in which users are deeply engaged with digital environments, experiencing focused attention, emotional involvement, and a heightened sense of presence (Agrawal et al., 2019; Janssen et al., 2016). While digital addiction is typically compulsive and associated with negative academic and psychological outcomes (Billieux et al., 2015), digital immersion, particularly within educational contexts, may coincide with academic motivation, adaptability, and cognitive engagement (Wu & Yuan, 2023; Alaleeli & Alnajjar, 2020). For instance, students participating in online or blended learning environments have reported enhanced academic agility and perceived learning advantages when they are fully immersed in tasks (Li et al., 2025; Grewe & Gie, 2023). Systematic reviews have noted variability in how digital immersion is defined across studies; however, a consistent theme is the purposeful and strategic use of digital tools aligned with pedagogical objectives (Nkomo et al., 2021). In engineering education specifically, students often engage in simulations, collaborative platforms, and online research that require the same technologies also used for digital leisure. This overlap blurs the line between academic and recreational screen time, suggesting that digital engagement should not be viewed in binary terms. Instead, immersive and self-regulated digital experiences, when intentionally managed, may correlate with improved AB (Renjith & Arundev, 2024; Wu & Yuan, 2023).

Indeed, some research has begun to highlight associations between high digital engagement and positive outcomes; for example, a recent meta-analysis confirmed that strong digital literacy skills are linked to better academic achievement (Li et al., 2025). Additionally, studies reinforce this complexity and advocate digital “detox” strategies to counteract

cognitive fatigue and improve academic focus (Radtko et al., 2022). Other studies highlight that the relationship of digital use varies greatly depending on the platform and purpose of use (Sha et al., 2019). In engineering programs specifically, the boundary between academic and non-academic digital activity is often blurred; students rely on the same devices and platforms for simulations, research, and coursework as they do for recreation and socialising.

Despite extensive international research on DB and its relationships with AB, substantial gaps remain in the literature concerning the Arab and North African contexts. Notably, North Africa has been reported to exhibit some of the highest global rates of internet addiction (Endomba et al., 2022), yet empirical insights specific to how DB relates to academic outcomes in this region remain limited. In Libya, the rapid expansion of internet infrastructure over the past decade has facilitated new academic opportunities but has simultaneously presented emerging behavioural challenges (Grifa, 2023). Engineering students are at the forefront of digital integration in higher education; therefore, they represent a critical population for examining the academic correlates of DB.

Libyan engineering students operate within distinct socio-educational conditions that may fundamentally reshape digital-academic dynamics. First, despite rapid internet expansion, the pedagogical hybridity sees traditional face-to-face instruction coexisting with imported digital tools, unreliable electricity/LMS access forces strategic offline adaptation (e.g., downloading resources during connectivity windows), a behaviour absent in digitally saturated universities. Secondly, creating unique tensions between prescribed technological immersion and culturally embedded learning preferences. Secondly, Social, some social media platforms are used cautiously due to cultural values, making “addiction” patterns distinct from Western or Asian cohorts, where unrestricted entertainment apps dominate.

This study accordingly analyses the academic associations of DB among engineering undergraduates at three major Libyan universities: Misurata University, Al-Asmarya Islamic University, and Al-Marqab University. It frames digital engagement as a spectrum ranging from harmful compulsive use to productive immersion and evaluates how this engagement correlates with AB. By examining behavioural trends and demographic variations in this understudied setting, the research seeks to inform targeted interventions that support students’ digital well-being and academic success.

2. Problem Statement

Engineering students today learn in an environment saturated with digital tools that support both education and recreation. While the integration of digital tools into higher education has enhanced access to knowledge, facilitated collaboration, and expanded the boundaries of learning, it has also introduced behavioural risks. Dominant among these is the concern of digital addiction, the compulsive and excessive use of smartphones, social media, gaming, and other digital platforms, often at the expense of academic focus and time management. What was once considered a personal behavioural issue has evolved into a broader phenomenon linked to educational implications.

In the Libyan context, empirical data are limited. Engineering students, given their dependence on digital tools, are potentially susceptible to both the benefits and drawbacks of pervasive digital use. Yet little is known about how their DB relates to AB, or how this relationship might vary by factors such as academic seniority or gender.

3. Hypotheses

This study is guided by the following research question: (1) What is the relationship between DB and AB among engineering students in Libya, and (2) how does this relation-

ship vary by academic year and gender? To examine the relationship between DB and AB, the study formulates and tests the following hypotheses:

- H_0 (Null Hypothesis): There is no statistically significant relationship between DB and AB.
- H_1 (Addiction Trend Hypothesis): There is a negative and statistically significant correlation between DB and AB, suggesting a potential trend toward academically disruptive digital engagement.
- H_2 (Immersion Trend Hypothesis): There is a positive and statistically significant correlation between DB and AB, suggesting a possible trend toward immersive digital engagement.
- H_3 (Group Differences Hypothesis): There are statistically significant differences in DB and/or AB based on students' academic year or gender.

4. Methodology

4.1. Research Design

The study adopted a descriptive-analytical research design. A quantitative approach was employed using a structured questionnaire, enabling the statistical examination of behavioural patterns and academic outcomes.

4.2. Participants and Sampling

The target population comprised undergraduate engineering students from three major Libyan universities: Misurata University, Al-Asmarya Islamic University, and Al-Marqab University. These institutions were selected to capture a diverse cross-section of engineering students in Libya, given their varying academic profiles and degrees of digital technology adoption. The selected universities follow a similar engineering curriculum and are located within a 90 km radius in northwestern Libya's urban coastal region, with pairwise distances ranging from 40 km to 90 km. These institutions share comparable internet accessibility and socio-cultural backgrounds. This geographic and academic alignment ensures consistency in the environments experienced by participants, reducing potential biases related to regional or institutional disparities while maintaining relevance to Libya's urban engineering student population.

A convenience sampling strategy was used, dictated by accessibility and the voluntary nature of participation. A total of 300 questionnaires were distributed in late 2024. After excluding incomplete or invalid submissions, 262 completed questionnaires were retained for analysis, yielding a response rate of approximately 87%.

The final sample comprised 166 male students (63.4%) and 96 female students (36.6%), reflecting the male-majority gender distribution often seen in engineering programmes in Libya. Participants spanned all years of the undergraduate curriculum; first-year students formed the largest group (23.7% of respondents), and fifth-year students the smallest (17.9%), with roughly 19–20% in each of the other years.

4.3. Research Instrument

Data were collected via a structured, self-administered questionnaire. The instrument consisted of 20 substantive items divided into 10 DB questions and 10 AB questions, see Table 1, plus additional demographic questions.

- The DB section measured students' engagement with digital technology, capturing behaviours associated with digital addiction (e.g., compulsive usage, procrastination due to online activities, digital distraction) as well as aspects of digital immersion (e.g., use of technology for academic purposes).

- The AB section assessed students' self-reported ABs and outcomes in the context of their digital use. Items focused on study habits and perceived AB. This scale is not a direct measure of grades, but rather students' perception of their academic efficacy and habits (which tend to correlate with academic success).

Table 1. All items used to measure DB and AB.

Independent Variable (DB) Items	
DB1	I spend more than 5 h daily online outside of study-related activities.
DB2	I use my smartphone during lectures or study time.
DB3	I find it difficult to stay away from social media while studying.
DB4	I feel an urgent desire to check notifications even during study time.
DB5	Using the internet affects the organisation of my study time.
DB6	I face difficulty in starting my studies due to being distracted by digital content.
DB7	I postpone my academic tasks due to browsing the internet or watching videos.
DB8	I use the internet or electronic games as a way to escape from academic stress.
DB9	I feel exhausted or tired due to prolonged nights spent on the internet.
DB10	I believe that my addiction to technology negatively impacts my academic and social life.
Dependent Variable (AB) Items	
AB1	I make sure to reduce the use of digital devices during study periods.
AB2	I am able to focus during study sessions without being distracted by digital content.
AB3	I complete my academic tasks on time without delay due to digital usage.
AB4	I am able to prepare for lectures and exams without digital addiction affecting my academic behaviour.
AB5	I am able to organise my time between studying and digital use in a balanced way.
AB6	I notice an improvement in my academic results when I reduce my use of non-educational digital content.
AB7	I am able to interact effectively with my peers and professors in an academic environment without the negative impact of digital addiction.
AB8	I have strategies to control my digital usage, which helps enhance my academic behaviour.
AB9	I make sure to use technology in a way that contributes to improving my academic level rather than hindering it.
AB10	I am able to complete academic research and projects without digital usage affecting the quality of the work

All items were formulated based on a critical review of prior literature and were reviewed by a panel of education and psychology experts to ensure content validity and clarity. The questionnaire employed a five-point Likert scale for responses (1 = Strongly Disagree up to 5 = Strongly Agree).

4.4. Reliability and Validity

Instrument reliability was evaluated using Cronbach's alpha (α) for both the DB and AB subscales, each consisting of 10 items. The internal consistency of both subscales was high, with $\alpha = 0.893$ for DB and $\alpha = 0.874$ for AB. This is well above the commonly accepted threshold of 0.70 based on [Nunnally and Bernstein \(1994\)](#). These results confirm that the items within each scale consistently measure their intended constructs. Table 1 lists all the items used to measure DB and AB for transparency and reference.

The questionnaire was originally developed in Arabic and then translated to English and reviewed for linguistic appropriateness in the local context; since the mother tongue of the participants is Arabic, the questions were presented in Arabic with no translation needed.

All responses were then coded and analysed using IBM SPSS Statistics (Version 23). Both descriptive and inferential statistical techniques were applied, as follows:

Before analysis, the Likert-scale coding was standardised such that higher numeric scores consistently indicate a greater presence of the attribute (more digital use for the DB items, and better academic-related behaviour for the AB items).

For descriptive purposes, average scores were loosely interpreted using a five-category scale aligned with Likert response anchors (from 1 = Strongly Disagree, to 5 = Strongly Agree). While these categories helped summarise overall trends in item-level responses, they were not used to categorise participants or perform any inferential analysis.

Additionally, a post hoc power analysis was conducted to evaluate whether the sample size was adequate to detect small effects. The analysis indicated that the sample ($N = 262$) provided >99% power to detect the observed correlation.

5. Results

The results are organised in the following four parts:

5.1. Digital Behaviour Among Engineering Students

Overall, the engineering students reported high levels of DB, much of which reflects potentially problematic or compulsive use. The mean of the composite DB score was 4.22 (on the 5-point scale), with a relatively low standard deviation (SD) = 0.55, indicating a consistently high agreement with statements indicating heavy digital involvement. Table 2 summarises the average scores for each DB item.

Table 2. Average scores and standard deviations for each DB item.

DB Item	DB1	DB2	DB3	DB4	DB5	DB6	DB7	DB8	DB9	DB10	Average
Average	4.53	4.37	4.34	4.27	4.18	3.74	4.13	4.08	4.1	4.45	4.22
SD	0.665	0.653	0.645	0.677	0.766	0.809	0.644	0.67	0.947	0.895	0.548
Rank	1	3	4	5	6	10	7	9	8	2	

The findings can be highlighted as follows:

- The highest-rated behaviour was related to excessive non-academic internet use. For instance, Item DB1 received the highest agreement (mean = 4.53, SD = 0.665). This suggests that a large portion of students spend a significant amount of time online unrelated to coursework, reflecting a prevalent habit of heavy daily digital consumption.
- Students demonstrated a strong recognition of potential negative associations with their digital habits. Notably, Item DB10 showed a high mean agreement score of 4.45 (SD = 0.895). While phrased using addiction terminology, this result suggests substantial student awareness of possible links between their digital behaviour and academic outcomes.
- Several items highlighted the interference of digital devices with study routines. For example, DB2 (mean = 4.37) and DB3 (mean = 4.34) were both among the top-rated behaviours. Such high means indicate that the majority of students frequently experience digital distractions during times that are meant for learning, reinforcing concerns that digital immersion can erode concentration and academic focus.
- On the lower end (though still above the neutral midpoint), DB6 had a relatively lower mean of 3.74 (SD = 0.809). This suggests that not all students struggle equally with initiating study activities in the face of digital distractions; some may have strategies to eventually get started, even if procrastination is common.

The combination of very high agreement regarding time-consuming online activity and frequent device checking, along with awareness of potential negative associations, suggests a cohort deeply engaged in digital life while navigating academic demands. These self-reported behaviours indicate students recognise challenges in balancing digital engagement with academic responsibilities.

5.2. Academic Behaviour in the Context of Digital Use

Despite the strong presence of digital distractions, students' self-reported AB were moderate to somewhat positive. The overall mean was 3.40 (SD = 0.518), indicating an average tendency to agree (or remain neutral) with statements describing effective academic habits and outcomes. This suggests that, as a whole, students did not perceive their academics to be severely impaired, nor did they overwhelmingly report optimal study habits. Table 3 summarises the average scores for each AB item.

Table 3. Average scores and standard deviations for each AB item.

Statement	AB1	AB2	AB3	AB4	AB5	AB6	AB7	AB8	AB9	AB10	Average
Average	3.27	3.31	3.2	3.3	4.13	3.16	3.4	3.11	3.75	3.38	3.4
SD	0.733	0.744	0.772	0.46	0.978	0.818	0.75	0.836	0.823	0.732	0.518
Rank	7	5	8	6	1	9	3	10	2	4	

Key observations from the AB items include the following:

- Among all academic behaviour items, AB5, related to students' ability to manage their time, received the highest mean score of 4.13 (SD = 0.978). Many students believed they could effectively manage their time despite digital distractions, indicating a degree of confidence or perceived control over their study schedule. This is an encouraging sign, hinting that students are at least aware of the need for balance and feel capable of it, even if their digital habits are heavy.
- In a similar vein, AB9 was relatively highly endorsed (mean = 3.75). This implies that a considerable number of students attempt to harness digital tools productively for their studies, reflecting an intention to convert digital immersion into academic gain.
- Conversely, the lowest-rated AB item was AB8 with a mean of 3.11 (SD = 0.836). This was the only item that hovered around a neutral response on average. This suggests that, although students recognise the need to control digital use, many have not yet developed practical, sustained strategies. This gap between awareness and action is also evident in AB6 (mean = 3.16), where students only mildly agreed, implying they do not fully perceive the academic benefits of reducing leisure digital activities.

Taken together, the AB results depict students as being partially successful in coping with the demands of their studies amid extensive digital engagement. They express confidence in their time-management and attempt to use technology beneficially, yet the lack of strong agreement on having concrete self-regulation strategies suggests many still struggle to effectively limit the distracting aspects of digital use. In essence, students know what they should do (balance and purposeful use) and believe they do it to some extent, but the consistency and efficacy of these efforts are questionable.

5.3. Investigating the Correlation Between DB and AB

From the radar chart shown in Figure 1, it is clear that the DB plot is markedly elevated relative to the AB plot, making it evident that DB scores are consistently higher than their AB scores across all areas. In other words, students report more intense digital involvement than positive AB.

Pearson's correlation was calculated across participants, using their composite DB and AB scores. For each of the 262 students, an individual average DB score and an average AP score were computed and used in the correlation analysis. This correlation ($r = +0.194$, with a 95% confidence interval (CI) [0.07, 0.31]) indicates a small effect size (Cohen, 1988), and the positive correlation means both variables increase in the same direction. This means that as DB scores increased (reflecting higher levels of digital immersion or use),

AB scores also tended to increase slightly. Although the correlation is weak in strength, the result is statistically significant with a p -value < 0.01 . Figure 2 shows a scatter plot of the composite average of DB scores against the average of AB scores, further confirming this relationship. The points in the scatter are widely dispersed, with no clear linear trend, although a slight upward slope is observable. Most students cluster towards the high end of DB and the mid-range of AB. The fitted trend line has a gentle positive slope, reflecting the weak positive correlation found statistically. The red line represents the regression fit, while the shaded red area depicts the 95% confidence interval, illustrating uncertainty in the predicted relationship.

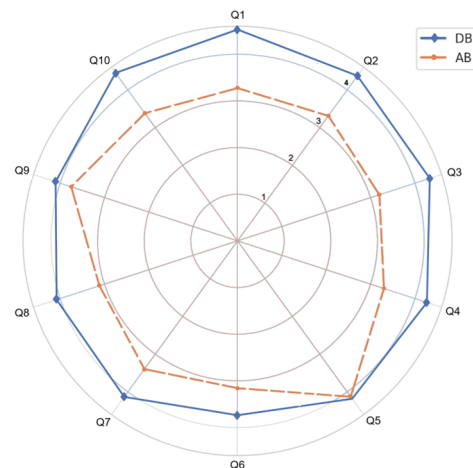


Figure 1. Radar Chart Comparing Average Scores of DB and AB.

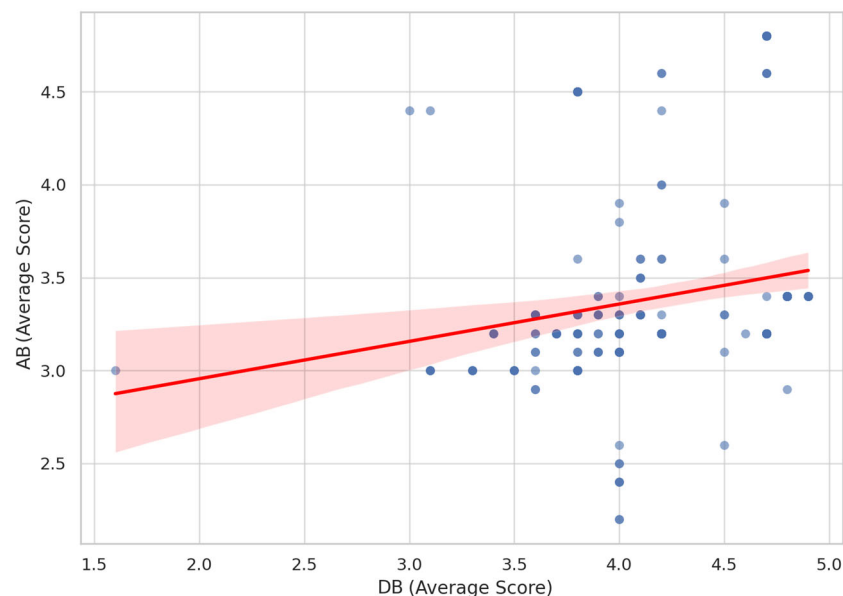


Figure 2. Average score of DB vs. AB for the 262 participants.

The broad scatter and clustering distribution demonstrate that, since many students scored near the maximum DB (a left-skewed distribution), there is limited variability in DB, which in turn constrains the observable correlation with AB, as seen in the histograms in Figure 3. Additionally, the distribution of AB scores was roughly symmetric to slightly right-skewed (fewer students reporting the absolute highest AB levels). There is not sufficient spread in behaviour scores to detect a strong relationship.

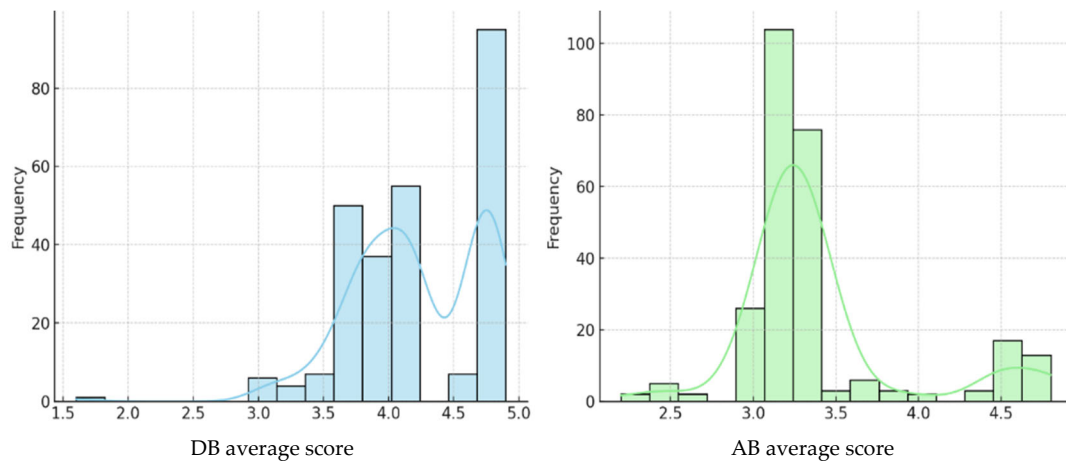


Figure 3. Histogram charts for DB and AB scores distribution.

This counterintuitive result suggests that heavy digital engagement does not necessarily correspond to lower AB; if anything, students with the very highest academic focus measures also reported high digital use. This outcome could imply that a number of students have integrated digital tools into their learning effectively, such that their extensive screen time includes productive study-related activities. In the context of engineering education, where computing and online research are part of the curriculum, being digitally active might even facilitate academic work.

It is important to stress, however, that the overall association is weak. The positive correlation, while statistically significant, does not suggest that DB determines academic outcomes. Rather, it indicates a complex scenario, where many students are deeply immersed in digital life, yet on average, this immersion shows no strong negative relationship with grades or study habits.

5.4. Differences by Academic Year and Gender

Given the evolving nature of student habits over the course of their studies, the study examined whether DB and AB differed significantly by year of study and also assessed differences by gender.

5.4.1. Differences by Year of Study

One-way analysis of variance (ANOVA) results revealed statistically significant differences across the five-year groups. For DB, the association of academic year was significant, $F(4, 257) = 52.49$, $p < 0.001$. The large effect size $\eta^2 = 0.45$ suggests that year of study explains approximately 45% of the variance in students' DB scores. First, second, and third-year students reported slightly *higher* average DB scores than those in later years; however, the differences, while statistically significant, were not very large in magnitude. The consistency of high digital use across all years was illustrated by boxplots (Figure 4); the median DB was high (around 4.2–4.3) for each year, and the interquartile ranges were relatively narrow, indicating that students in every year exhibit strong digital engagement. A modest decline in median DB for fourth- and fifth-year students was observable, hinting that senior students might exercise a bit more restraint or have less leisure time.

For AB, ANOVA also showed significant differences by year of study, $F(4, 257) = 14.86$, $p < 0.001$. $\eta^2 = 0.19$, indicating a large effect size. Here, the trend was clearer, mean AB scores were lowest in the early years and highest in the later years. In particular, first-year students had the lowest self-rated AB (with many struggling to manage digital distractions), whereas fourth- and fifth-year students indicated notably better AB scores. Figure 5 demonstrates this upward progression in AB scores by year.

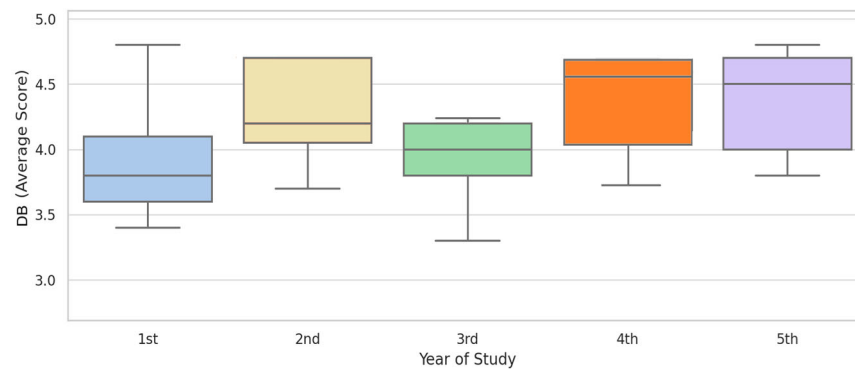


Figure 4. DB per year of study.

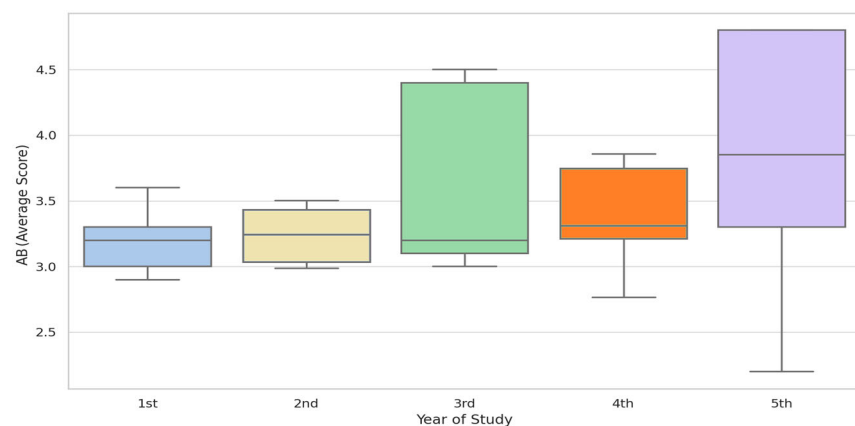


Figure 5. AB per year of study.

These results suggest a developmental trajectory, as students progress through their engineering programme, they tend to improve their academic discipline and ability to balance or integrate digital tools with their studies, even though their overall level of digital engagement stays high. Early-year students may be more prone to digital distraction and less experienced in self-regulation, leading to a bigger gap between their heavy digital use and moderate AB. By contrast, by the fourth or fifth year, many students seem to have adapted—finding ways to maintain or even improve their AB without substantially cutting back on digital involvement. This aligns with the idea that academic maturity and self-regulated learning skills develop over time, especially in a demanding field like engineering.

5.4.2. Differences by Gender

The analysis by gender revealed that male and female students did not differ significantly in overall DB; both groups showed similarly high levels of digital engagement, with a mean DB of roughly 4.2 for males vs. 4.1 for females. This suggests that, in the context of these engineering students, both men and women are equally immersed in the digital world. A one-way ANOVA revealed a statistically significant difference in DB between male and female students, $F(1, 260) = 11.39$, $p = 0.0009$, $\eta^2 = 0.042$ (small effect). While both genders exhibited high digital engagement, female students scored slightly lower in DB, indicating somewhat more controlled or less excessive use. Boxplots of DB by gender showed almost overlapping distributions, see Figure 6, with a marginally higher median for males but considerable overlap in the range of scores for both groups. However, when it came to AB, female students outperformed their male counterparts on average.

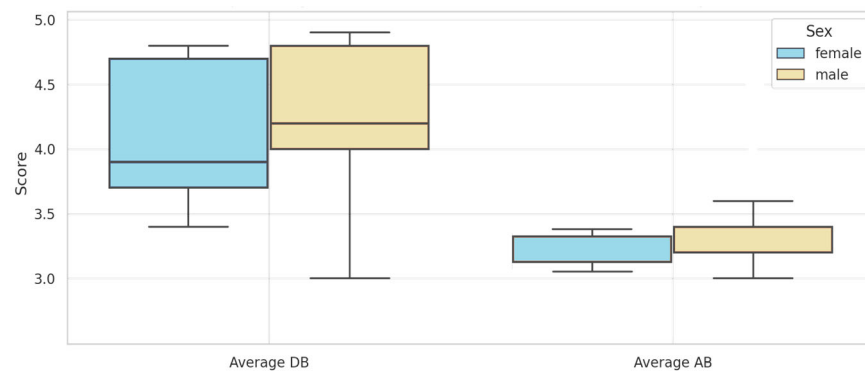


Figure 6. DB and AB per gender.

DB also differed significantly by gender, $F(1, 260) = 26.52, p < 0.001$, with a moderate effect size ($\eta^2 = 0.09$). Female respondents tended to report slightly better academic outcomes and study habits (mean AB for females was higher than for males). The AB boxplots by gender illustrated that females had a higher median AB, suggesting more consistency in their AB. One interpretation is that female students may be better at balancing digital engagement with academic demands, perhaps due to higher self-discipline or different usage patterns (Sha et al., 2019).

It is also possible that female engineering students, being fewer in number, represent a self-selected group with particularly strong motivation and organisation, which could reflect in their AB.

6. Discussion

This study investigates the relationship between DB and AB among engineering students, focusing on how this association varies by academic year and gender. The findings provide several insightful perspectives on this issue.

6.1. Digital Behaviour vs. Academic Behaviour Relationship

The study revealed a weak yet statistically significant positive correlation ($r = +0.194$) between DB and AB. This modest accounts for approximately 4% of the variance in AB, indicating that DB alone is not a primary determinant. These data suggest that in this sample of engineering students, those who are heavily engaged with digital media are, if anything, doing slightly better academically, or at least not doing worse. This aligns with emerging perspectives in the literature that draw a distinction between pathological digital overuse and productive digital engagement. Etchells (2024) argues that it is overly simplistic to view all screen time as bad, and our findings echo that sentiment.

One explanation is that many engineering students may leverage digital tools for their studies. High DB scores likely include significant academic usage, which could boost performance. For example, many students agreed with items like using technology to improve their academic level (AB9) and managing study time despite device use (AB5). The positive role of digital skills is supported by literature, digital literacy and purposeful technology use have been linked to higher academic achievement (Li et al., 2025; Wu & Yuan, 2023).

Furthermore, Renjith and Arundev (2024) found similar modest positive correlations, noting that specific dimensions of DB can indeed contribute constructively to academic success when effectively integrated into academic activities. This aligns with the perspective that students who are adept at navigating digital environments may concurrently enhance their educational performance.

Another contributing factor could be the adaptation of students to constant connectivity. Today's undergraduates have grown up as "digital natives" and likely possess a baseline proficiency for multitasking and swiftly transitioning between digital and non-digital tasks. Thus, what earlier generations of educators would view as a harmful distraction might be the "new normal" that students have learned to manage. However, it remains critical to note that our observed correlation, though positive, is weak, underscoring that DB alone is not a primary determinant of academic achievement. The weak strength of the correlation is key. It indicates DB is far from the sole determinant of academic success. Factors such as individual self-discipline, study habits, cognitive ability, and institutional support likely play much larger roles in driving academic outcomes, with DB being just one piece of a complex puzzle.

These results notably contrast with previous studies in similar contexts, which found explicit negative associations of excessive digital engagement with AB. Samaha and Hawi (2016) reported a statistically significant negative correlation between smartphone addiction risk and AB among Lebanese university students. Similarly, Boumosleh and Jaalouk (2018) observed negative relationships between smartphone addiction and academic outcomes among students in the region. In addition, in an older investigation, there was no direct or indirect link between learning self-efficacy and smartphone addiction (Chiu, 2014). These discrepancies may arise due to differences in study populations; engineering students might exhibit superior digital skills or require higher levels of digital interaction as part of their curriculum. Additionally, the increased integration and normalisation of digital technologies in recent years may have influenced some historically observed associations in earlier studies.

6.2. Academic Maturity and Digital Self-Regulation

One of the clearest patterns in the data was the improvement in AB indicators as students progressed through their academic years (from first to fifth year), even though their DB remained high throughout. A one-way ANOVA confirmed that this trend was statistically significant across academic years, with $p < 0.001$ in both AB and DB, with a large effect size ($\eta^2 = 0.19$ and $\eta^2 = 0.45$, respectively), indicating that the year of study accounts for substantial variance in both constructs. First-year students tended to have lower academic focus and were perhaps more overwhelmed by digital distractions, whereas by the fifth year, students showed significantly better academic self-management without a major drop in digital engagement. This finding is in line with general theories of student development and self-regulated learning; as students advance, they typically develop stronger study skills, time management techniques, and metacognitive strategies. The results imply that academic maturity helps convert DB from a liability into a more neutral or even positive factor. It resonates with findings from other contexts that older students often employ more effective self-regulation and have had time to witness the consequences of procrastination and thus adjust their habits (Khan et al., 2020).

During the initial university years, students often undergo a transition period, adjusting to greater freedom and the onslaught of digital entertainment and social connectivity that comes with campus life. Many first-year participants reported checking phones in class, spending hours online nonstop, and struggling to initiate study sessions, classic symptoms of digital distraction. These issues contributed to comparatively poorer AB in those early years.

6.3. Gender and Digital-Academic Interactions

It was observed that male and female engineering students had virtually identical levels of digital engagement, but female students reported slightly stronger AB, with

moderate ($\eta^2 = 0.09$) and small ($\eta^2 = 0.042$) effect sizes, respectively. This result aligns with some existing literature suggesting that female students, on average, may exercise better academic self-discipline or time management in the face of distractions (Sha et al., 2019). One interpretation is that female students in male-dominated fields (like engineering) might be especially motivated to prove themselves, thereby maintaining strong AB even if they use digital media extensively.

It is worth noting that the gender gap in AB, while statistically significant, was not substantial. The vast majority of both male and female students were heavily immersed in digital life, and many of both genders managed to maintain their AB. This suggests that gender is not a strong moderator of the relationship between DB and AB.

7. Conclusions

This study explored the interplay between DB and AB among undergraduate engineering students in Libya. The results contribute to a more nuanced understanding of how digital engagement shapes students' academic experiences in an era of widespread technological immersion.

We found that DB and AB are weakly positively correlated in this cohort, challenging the common assumption that high levels of digital activity necessarily lead to academic decline. Engineering students, as a group, demonstrated that they can be constantly online and yet maintain reasonable AB. Particularly among senior students, AB improved despite consistently high digital use, indicating a developmental progression towards mature digital immersion rather than debilitating digital addiction. In other words, as students advanced in their studies, they appeared better able to integrate technology into their academic routines without suffering adverse effects; the line between learning and digital leisure became better managed.

At the same time, the study confirmed that many students struggle with digital distractions, especially in the earlier years of their degree. A considerable proportion reported difficulties in concentrating, procrastination due to online content, and awareness that their academic potential is not fully realised because of their digital habits. There is a clear recognition among students of these pitfalls, yet a gap remains between recognising the problem and having effective strategies to address it.

These findings highlight a critical need for universities to reframe the conversation around digital use. Institutions should focus on empowering students with the skills and strategies to harness digital tools for academic success. This means treating digital literacy and self-regulation as core competencies to be cultivated, much like subject-matter knowledge. For example, incorporating training on digital self-management in the curriculum, creating awareness about the potential academic benefits of mindful technology use, and providing support for those who are genuinely overusing digital media can all form part of a comprehensive approach.

In conclusion, in a digitalised academic environment, the boundary between addiction and immersion is not clear-cut. Engineering students in this study were not simply victims of technology's allure; many of them were actively negotiating their relationship with technology, sometimes faltering but often finding ways to let their digital engagement coexist with their learning. With appropriate guidance and support, students can be taught to transform what might begin as problematic DB into a more productive digital immersion that supports their academic and professional growth. The narrative, therefore, shifts from "technology as foe" to "technology as a potential friend", one that must be managed and understood, but which can ultimately become an invaluable asset in a student's educational journey.

8. Recommendations

In light of these findings, the study proposes several recommendations to promote healthier DB and enhance AB among engineering students. The following recommendations are directed at different stakeholders in the education process, universities, students themselves, and future researchers:

1. **Universities:** Universities should offer standalone workshops (or workshops as part of a module) on managing DB, particularly as part of a curriculum for first-year engineering students transitioning into new academic expectations and a new digitally mediated educational environment. These workshops need to include effective strategies immediately implementable by students, such as identifying digital distractions, time management skills, and using technology to support learning rather than derail learning. In addition to promoting effective DBs, universities could encourage the use of productivity apps and tools that can help students monitor and control their screen time, so students can, rather than only seeking to improve DBs, establish digital habits that are sustainable.
2. **Students:** Students need to distinguish clearly between their academically based digital activities and digital leisure activities. Tactics such as creating separate user profiles or browser accounts (one for study and another for recreation) are an example of practical strategies that can create a mental “boundary” between digital study and leisure; if a mental separation is established, students will be less susceptible to distraction by digital media. Moreover, students should build habits of self-monitoring, such as keeping a digital diary, and reflecting on their DB’s contributions to study their productivity and levels of stress. This type of self-monitoring would help students become aware of their digital habits, although enhanced awareness may alter their subsequent behaviour.
3. **Academic support services:** Universities need to diversify academic support services to include direct support for individual students via counselling activities and digital literacy coaching; effective academic support needs to “help the student identify their individual behaviours”. Universities can offer peer support groups and campaigns for digital wellness and academic success that help develop social capital that values a community/collective disposition toward mindful technology.
4. **Future Research:** To further investigate the link between DB and AB, future studies are encouraged to correlate DB scores with objective academic indicators, such as semester GPA or final course results. This would help validate the relationship between digital engagement and academic outcomes more reliably than self-reported AB alone. It is also recommended that researchers longitudinally track digital behaviour to see how it changes over time and how those changes relate to overall academic progression. Establishing this type of causal link between digital behaviour and academic achievement would also help to identify important points in time to intervene with students.

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Abbreviations

The following abbreviations are used in this manuscript:

ANOVA	Analysis of Variance
AB	Academic Behaviour
DB	Digital Behaviour
GPA	Grade Point Average
SPSS	Statistical Package for the Social Sciences

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