

Impact of Addictive Use of Cell Phones in Medical University Students Developing Distortion of Skills in Practical Life in Pakistan

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Abstract

The current study explored the effect of addictive smartphone use on medical university students in Pakistan regarding their clinical practical skills self-efficacy, by investigating daily cognitive failures and face-to-face communication skills as mediators, and digital self-regulation as a moderator. The quantitative cross-sectional design was used to analyze the data of 550 MBBS students using PLS-SEM in SmartPLS 4. This study revealed a significant correlation between addictive smartphone use and cognitive failure, as well as a significant decrease in communication skills and clinical practical skills self-efficacy. Communication skills had a positive impact on self-efficacy, while cognitive failures had a negative impact. The mediation effect was also found to be significant and Digital self-regulation reduced the adverse effect of addictive smartphone use on cognitive failures. The model accounted for 52.2% of the variance in clinical

practical skills self-efficacy and had a significant predictive capacity for medical education based on the CVPAT.

Introduction

The smartphone has become an integral part of medical education, offering students clinical reference, learning platforms, communications, and decision-support resources. Their educational value will depend on use, however. Scholarship involves a goal-oriented use of the smartphone rather than problematic or addictive behavior with loss of control, compulsive checking, preoccupation, and functional impairment (Nawaz, 2024). This distinction is relevant especially for medical students who have to acquire long-term concentration, interpersonal skills, psychomotor skills, and assurance in performing clinical procedures during their training. The results of the meta-analysis suggest problematic smartphone use is linked to lower academic performance, whereas

longitudinal evidence suggests problematic use and student disengagement may perpetuate each other over time (Paterna et al., 2024; Yu, 2026).

The issue is pertinent in Pakistan as the mobile phone has become a part of university life and medical education. The data from Pakistani medical students reveals a trend of overuse, withdrawal, tolerance, relationships with cyberspace and disturbance of daily life (Naeem et al., 2024). The studies conducted in Pakistan have also found that smartphone addiction is associated with decreased school performance, psychological problems, oculomotor strain, cervical disability, and headache burden (Hassan et al., 2024; Syed et al., 2025). However, the literature has tended to focus on academic performance, psychological well-being, sleep, or physical symptoms as end results. Less is known, however, about whether addictive smartphone use negatively affects some of the essential aspects of medical practice.

This gap is significant because excessive use of the smartphone can impact clinical development in cognitive and interpersonal ways. Smartphone addiction and failures in self-regulation have been linked to higher levels of mind wandering and everyday cognitive failures, which indicate a disruption of attention, memory, and task performance when one is distracted by the smartphone (Al-Abyadh et al., 2024). Medical training also relies on hands-on experience, active listening, patient interaction, and face-to-face communication, which may be compromised by a decreased amount of the latter, potentially impacting students' confidence in learning and performing clinical skills. Learners' clinical-skills self-efficacy is defined as students' perceptions of their ability to learn and perform clinical tasks, and has been associated with learning and performance (Kang et al., 2019).

Based on this, the current study aims to propose an integrated model that medical university students in Pakistan are more likely to have lower clinical practical skills self-efficacy directly from addictive smartphone use and indirectly through daily cognitive failures and face-to-face communication skills. It also proposes a moderation effect of digital self-regulation, which reduces the negative impact of addictive smartphone use on cognitive failures. The study focuses on professional readiness and how digital addiction can manifest as a decrease in competence in areas other than academic consequences, which explains why the focus is on cognitive, communicative, and practice-related competence.

Theoretical Linkage

This framework was based on the Interaction of Person-Affect-Cognition-Execution (I-PACE) model and self-efficacy theory, which have been used to explain the cognitive, interpersonal, and performance consequences that may arise from addictive smartphone use (Brand et al., 2019; Yong & Roberts, 2025). The I-PACE model indicates that problematic technology use involves cue-reactivity, craving, cognitive responses, and impaired inhibitory control, and recent studies have highlighted smartphone addiction as being related to self-regulation problems, mind wandering, and cognitive failures (Brand et al., 2019; Al-Abyadh et al., 2024; Zhang et al., 2024). The daily cognitive failures were placed as a mediator due to the cognitive fragmentation caused by addictive smartphone behaviors, along with absent-mindedness and task-related cognitive impairment (Al-Abyadh et al., 2024; Zhang et al., 2024; Li et al., 2025).

The second mediator was face-to-face communication skills, as excessive smartphone usage and phubbing can negatively affect listening skills, responsiveness, eye contact, and quality of communication (Su et al., 2024; Başgöl & Rüzgar, 2025; Şimşek & Başaran, 2025). This mechanism is relevant to medical education where communication, history taking, and patient interaction are essential to clinical competence as well (Yong & Roberts, 2025; Chao & Liang, 2025). Clinical practical skills self-efficacy was selected as the distal outcome as it is a result of attention, practice, reflection, communication, and mastery experiences (Yong & Roberts, 2025; Chao & Liang, 2025; Biagioli et al., 2025).

Digital self-regulation was added as a protective moderator since it has been found that greater self-regulation is associated with controlling smartphone impulses, maintaining attention to task, and decreasing problematic smartphone use (Al-Abyadh et al., 2024; Xiao et al., 2025; Bibi et al., 2025). The relevance of the framework is supported by Pakistani evidence, as medical students suffer from overuse, withdrawal, tolerance, cyberspace-oriented relations, and disturbance in daily life related to their smartphones (Naeem et al., 2024). This, in turn, suggests that the relationship between smartphone addiction and clinical ability is reversed, whereas the relationship between smartphone addiction and digital self-regulation is inverted, indicating that the consequences of smartphone use on cognition may be diminished with the application of digital self-regulation (Brand et al., 2019; Al-Abyadh et al., 2024; Bibi et al., 2025).

Hypotheses Development

Addictive Smartphone Use and Daily Cognitive Failures

When smartphones become addictive, they can interfere with cognitive abilities that are essential for the tasks at hand, such as sustained attention, working memory, and monitoring of ongoing activity, as checking and cues are constantly pulling attention back to the smartphone (Brand et al., 2019; Al-Abyadh et al., 2024). A study conducted in a university revealed that the frequent use of a smartphone significantly reduces the attention of the students and causes them to wander their thoughts, experience forgetfulness, distraction from focus, and inability to complete their tasks (Al-Abyadh et al., 2024). More recent studies also show a positive correlation between mobile phone addiction and cognitive failure, with the involvement of self-control and mind wandering accounting for part of this correlation (Li et al., 2025). These cognitive effects are especially important for medical students, who are constantly learning and need to be vigilant and process complex information correctly. Therefore:

H1: Addictive smartphone use positively influences daily cognitive failures among medical university students.

Addictive Smartphone Use and Face-to-Face Communication Skills

Active listening, eye-to-eye contact, interpersonal responsiveness and focusing one's attention on the social cues of the other person in the conversation are all crucial skills required for face-to-face communication that can be interrupted by engagement with a smartphone during social interaction (Celikkalp et al., 2020; Başgöl & Rüzgar, 2025). A study conducted with medical and nursing students identified that the higher the score on the smartphone addiction scale, the lower the scores on the communication skills scale and interpersonal communication scale were (Celikkalp et al., 2020). The literature also provides recent evidence showing that phubbing has a negative relationship with communication skills, as the smartphone-focused attention disrupts verbal and non-verbal communication (Başgöl & Rüzgar, 2025). Communication with patients, colleagues, and clinical supervisors is a key part of the learning process in medical schools, and the excessive use of a smartphone could increasingly undermine the ability to communicate effectively with others. Therefore:

H2: Addictive smartphone use negatively influences face-to-face communication skills.

Daily Cognitive Failures and Clinical Practical Skills Self-Efficacy

Students need not only to remember procedures in clinical practical but also to grasp clinical principles and accurately sequence the actions required, hold attention, and perform the learned procedures accurately (Kang et al., 2019). Cognitive failures are

the everyday lapses in attention, memory, and action control, and recent research has shown that these failures have a negative impact on how students function academically and how they experience learning (Al-Abyadh et al., 2024; Li et al., 2025). Errors, lack of recall of the procedure, or challenges in maintaining focus may hinder some experiences of mastery and lead to a loss of self-efficacy beliefs. Clinical-skills self-efficacy is related to students' confidence in recalling, explaining, applying, and demonstrating clinical procedures, so students who have frequent cognitive failures should perceive themselves as being less able to successfully perform practical clinical tasks (Kang et al., 2019). Therefore:

H3: Daily cognitive failures negatively influence clinical practical skills self-efficacy.

Face-to-Face Communication Skills and Clinical Practical Skills Self-Efficacy

Because history-taking, giving instructions, interpreting patient responses, building rapport, and coordinating clinical activities with other health care professionals are all a part of medical students' clinical performance, communication is integral to it. In recent years, studies among medical students have shown that communication skills are positively correlated with self-efficacy in medical treatment, and self-efficacy is an important predictor even after other factors affecting learning are taken into account (Je et al., 2024). Studies involving healthcare students also show that students' communication skills are positively correlated with self-efficacy prior to their clinical experience (Kim & Park, 2023). Communication practice also works as a vehicle to create successful interpersonal and clinical experiences for students where they can build up confidence in how to approach and interact with actual patients. Therefore, students' confidence in their ability to perform practical clinical activities should be enhanced by their better face-to-face communication skills. Therefore:

H4: Face-to-face communication skills positively influence clinical practical skills self-efficacy.

Addictive Smartphone Use and Clinical Practical Skills Self-Efficacy

Distraction, decreased engagement in learning, self-regulation, and the displacement of these activities that are necessary for developing skills are all factors that can compromise learning when smartphone usage is problematic (Brand et al., 2019; Paterna et al., 2024). In a recent meta-analysis with almost 48,490 participants, problematic smartphone use was found to be negatively associated with academic performance, which supports the idea that problematic smartphone use can impair educational functioning (Paterna et al., 2024). Additionally, there is strong evidence that health-profession students who are more likely to be addicted to their smartphones have lower levels of self-efficacy (Kim & Park, 2023), and that university students with problematic smartphone use tend to have lower self-efficacy in their domain of study (Li et al., 2024). Medical students in Pakistan already experience overuse, withdrawal, tolerance, and disturbance in daily life due to their use of smartphones (Naeem et al., 2024). Thus:

H5: Addictive smartphone use negatively influences clinical practical skills self-efficacy.

Mediating Role of Daily Cognitive Failures

The negative consequences of problematic digital behaviors are hypothesized to occur via cognitive and executive processes, not just behavioral ones (Brand et al., 2019), as suggested by the I-PACE model. Recent studies have established that the cognitive failures and mind wandering of university students are downstream effects of mobile-

phone addiction, through its downstream effects on self-control and attention (Li et al., 2025), and that smartphone addiction has been shown to impact cognitive failures among university students (Al-Abyadh et al., 2024). Smartphone addiction may negatively affect self-efficacy in clinical skills because it can lead to memory problems, cognitive disorganization, and failure to perform clinical procedures successfully, which, in turn, can lead to a decreased ability to successfully perform clinical skills (Kang et al., 2019). Accordingly:

H6: Daily cognitive failures mediate the relationship between addictive smartphone use and clinical practical skills self-efficacy.

Mediating Role of Face-to-Face Communication Skills

Part of the impact of addictive smartphone use on clinical self-efficacy is on other clinical self-efficacy communication. In medical and nursing students, more smartphone addiction has been correlated with poorer communication skills, highlighting the negative impact of excessive mobile use on interpersonal functioning in health-profession education (Celikkalp et al., 2020). Recent studies also indicate that the use of the smartphone is a significant predictor of the communication skills of healthcare students (Başgöl & Rüzgar, 2025). Communicative skills, in turn, have been positively linked with general self-efficacy of nursing students and medical-treatment self-efficacy of medical students (Kim & Park, 2023; Je et al., 2024). These results indicate a possible cascading process, in which smartphone addiction affects interpersonal ability, followed by a decrease in confidence in solving real-world clinical problems. Therefore:

H7: Face-to-face communication skills mediate the relationship between addictive smartphone use and clinical practical skills self-efficacy.

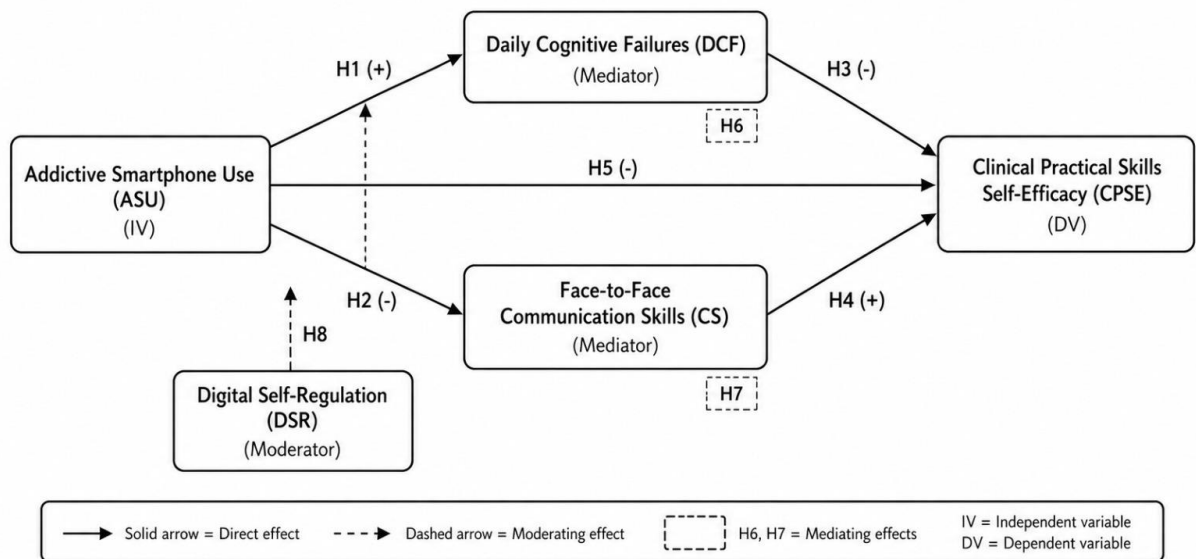
Moderating Role of Digital Self-Regulation

Self-regulation is the key to whether people can regulate their immediate digital reactions and behave in ways that align with their long-term academic and/or career objectives (Brand et al., 2019). Findings from recent studies indicate that self-regulation failures are positively correlated with both smartphone addiction and cognitive failures in university students (Al-Abyadh et al., 2024), and longitudinal evidence reveals that self-regulation is an important protective factor in the emergence of problematic smartphone use among university students (Xiao et al., 2025). In specific evidence, it has been shown that trait self-regulation has the potential to moderate the negative relationship between mobile-phone addiction and daily cognitive failures, suggesting that the more self-regulated one is, the better one can cope with problematic mobile use in terms of cognitive functioning (Hong et al., 2020). Self-regulated medical students, therefore, ought to be able to better suppress unnecessary checking, resist notifications, and have the ability to sustain attention in learning and clinical activities in an electronic self-regulation format. Consequently:

H8: Digital self-regulation negatively moderates the relationship between addictive smartphone use and daily cognitive failures, such that the harmful relationship becomes weaker at higher levels of digital self-regulation.

Conceptual Research Framework

Impact of Addictive Smartphone Use on Clinical Practical Skills Self-Efficacy among Medical University Students in Pakistan



Methodology

Research Design

The study was a quantitative, explanatory, cross-sectional design to explore the clinical practical skills self-efficacy mediated by daily cognitive failures, face-to-face communication skills, and moderated by digital self-regulation, which was found to influence the relationship between addictive smartphone use and clinical practical skills self-efficacy. A quantitative design was appropriate as the proposed relationships were theoretically specified and needed to have the direct, indirect, and interaction relationships estimated at the same time. The study is based on a causal-predictive perspective and uses partial least squares (PLS) Structural Equation Modeling (SEM), which is applicable for causal-predictive perspective, mediation and moderation, multiple latent constructs, and prediction-oriented objectives (Hair & Alamer, 2022).

Population and Sample Size

The study focused on undergraduate MBBS students at recognized medical universities/colleges, both governmental and non-governmental, in Pakistan. This study specifically included third, fourth, and final year students as they had been given an adequate amount of exposure to clinical practical skills laboratories, bedside learning, patient interaction, and practical clinical activities to be able to meaningfully assess the clinical practical skills self-efficacy. The students were eligible if they were currently enrolled in the program, used a smartphone for at least one year, and had completed clinical and/or practical training. Students from first and second year were not included due to the limited exposure they had to the clinical practice.

An optimal target number of 550 usable responses was set. This relatively large sample size was chosen to ensure sufficient statistical power in the tests of direct effects, two mediation pathways, and interaction effects, and to account for the specific interhospital, inter-clinical-year, and inter-demographic differences. The target was also very high compared to the usual and necessary conditions for PLS-SEM, and gave more stability with bootstrapping and predictive evaluation (Hair & Alamer, 2022). The number of questionnaires was planned to be approximately 700 – 750 to provide for missing questionnaires, non-response, and questionnaires that do not meet data-quality screening requirements.

Sampling Technique

A multistage stratified sampling technique was used to ensure a representative sample of medical education in Pakistan. In the first phase, medical universities/colleges were classified by geographic region and type of ownership (public or private). To reduce geographical concentration, institutions across major geographical regions were taken into consideration, such as Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan, and Islamabad Capital Territory.

In the second stage, the participating institutions were classified based on their clinical year (3rd, 4th, and final year). The questionnaires were then distributed in proportion to the number of eligible students in each of the participating institutions and academic year. For the selected strata, students were approached through class lists or institutional student groups, if available. This was done in an attempt to make the sample more homogeneous and prevent the results being a reflection of students from just one university, province or academic year.

Measurement Instrument

A structured self-administered questionnaire was used to collect data. Whenever possible, existing and psychometrically tested measures were used. A few items were changed slightly in their wording to suit the context of Pakistani medical students. The questionnaire consisted of 62 measurement items for the five constructs of the study.

Table 1: Measurement instrument

Construct	Role	Measurement source	No. of items
Addictive Smartphone (ASU)	Use Independent variable	Smartphone Addiction Scale–Short Version, Kwon et al. (2013)	10
Daily Failures (DCF)	Cognitive Mediator	Cognitive Failures Questionnaire 2.0, Goodhew & Edwards (2024)	15
Face-to-Face Communication Skills (FCS)	Mediator	Global Interpersonal Communication Competence Scale, based on Rubin & Martin (1994) and subsequent health-science applications	15
Clinical Skills (CPSE)	Practical Self-Efficacy Dependent variable	Learning Self-Efficacy Scale for Clinical Skills, Kang et al. (2019)	12
Digital Regulation (DSR)	Self-Moderator	Smartphone-context self-regulation items adapted from Liu et al. (2026)	10
Total			62 items

The 10-item Smartphone Addiction Scale–Short Version (SAS-SV) created by Kwon et al. (2013) was used to assess addictive smartphone use. The scale measures loss of control, withdrawal, excessive use, preoccupation, and disruption of daily functioning, and showed good reliability and validity during its initial construction.

The 15-item Cognitive Failures Questionnaire 2.0 (CFQ 2.0) was used to assess daily cognitive failures, developed by Goodhew & Edwards (2024). This instrument reflected failures of attention, memory, concentration, and action control that are currently happening in the everyday lives of everyone and showed good stability across the items, across test-retest, and across associations to objective measures of attentional control. The components of face-to-face communication skills were measured by 15 items in Global Interpersonal Communication Competence, which included competencies like empathy, concentration, responsiveness, self-disclosure, assertiveness, interaction

management, expressiveness, supportiveness, and social appropriateness. This 15-item measure has been applied in health-profession education and recent studies in the healthcare field (Han et al., 2024).

The 12-item Learning Self-Efficacy Scale for Clinical Skills (L-SES) was used to assess clinical practical skills self-efficacy that was specially developed for undergraduate medical students by Kang et al. (2019). The scale measures students' confidence in their recall, understanding, explanation, application, analysis, evaluation, and performance of clinical skills, and was designed specifically as a generic scale to be applicable to clinical procedures.

The items for the digital self-regulation were operationalized by the smartphone-related Self-Regulation Questionnaire used by Liu et al. (2026), which contained 10 items. The measure represented four regulatory capabilities—monitoring smartphone behavior, planning usage limits, inhibiting smartphone-related impulses, and regulating emotion-driven smartphone use. The initial smartphone-context measure was found to be reliable and construct-valid in the context of University students.

Adapted items were presented on a seven-point Likert scale (1 = strongly disagree to 7 = strongly agree) to ensure the measurement was consistent. The questionnaire was preliminarily reviewed by medical education researchers, behavioral researchers, and quantitative methodology experts before the main survey, in order to check for contextual relevance and wording. The pilot test involved about 40-50 medical students for the purposes of testing clarity, completion time, and preliminary reliability, but was not included in the sample of students. Demographic questions included gender, age, academic year, type of institution, average daily smartphone use, and an estimate of whether academic or nonacademic smartphone use was greater.

Data Collection

Data collection was conducted through participating medical universities after obtaining institutional permission. Both **online and paper-based questionnaires** could be used depending on institutional accessibility, although identical wording and response formats were maintained across modes. Students received a brief explanation describing the academic purpose of the study, voluntary nature of participation, confidentiality of responses, and their right to withdraw before submitting the questionnaire.

A screening question confirmed that respondents were currently enrolled MBBS students in an eligible clinical year and regular smartphone users. No personally identifying information was requested. Responses were screened for substantial missing data, duplicate submissions, extremely short completion times, invariant response patterns, and other indications of careless responding.

Data Analysis Techniques

Both SPSS 23 and SmartPLS 4 were used to analyze the data. Coding, screening for missing data, descriptive statistics, demographic profile, evaluating the response pattern, and initial data cleaning were carried out using SPSS. To assess non-response bias, comparisons were made between early and late respondents on main study constructs. Procedural steps taken to minimize common-method bias were: anonymity, separation of predictor and criterion sections of the questionnaire, neutral wording of the questionnaire, and the assurance that there were no objectively right or wrong responses. The measurement and structural model were followed in the recommended two stages procedure for PLS-SEM analysis (Hair & Alamer, 2022). The outer loadings and internal consistency (Cronbach's alpha, rho_A and composite reliability) in the measurement model were examined. The satisfactory range of values was 0.70 to 0.95. Average variance extracted (AVE) was used for convergent validity and heterotrait-monotrait ratio (HTMT) was used for the primary test of discriminant validity with the

criterion of 0.50 and below of 0.85 – 0.90 respectively for the constructs to indicate adequate construct distinctiveness.

The structural model was then tested for the relationship between variables, path coefficients, coefficient of determination (R²), effect sizes (f²), and the predictive value (Q²). The 10,000 bootstrap subsample number was used to assess the significance of the hypotheses, and standardized path coefficients, t-statistics, p-values, and 95% confidence intervals were determined, resulting in more stable estimates of the hypotheses in the final PLS-SEM analysis.

The proposed mediation by H6 and H7 were assessed by the bootstrapped specific indirect effects of addictive smartphone use on clinical practical skills self-efficacy with daily cognitive failures and face-to-face communication skills, respectively.

The interaction between Addictive Smartphone Use and Digital Self-Regulation was developed in SmartPLS 4, and the interaction effect was estimated as an influence on digital self-regulation in the context of daily cognitive failures for H8. The negative interaction coefficient was large, suggesting that there was a moderation effect such that higher scores on digital self-regulation reduced the negative association between addictive smartphone use and cognitive failures.

Finally, the predictive ability testing of the model was conducted using the Cross-validated predictive ability testing (CVPAT) approach in SmartPLS 4 to test the proposed model, which gave a significant prediction compared to the relevant benchmark model. This combination allowed for the analysis to not only confirm the hypothesized relationships statistically, but to also determine the explanatory and predictive power of the framework.

Findings and Analysis

Measurement Model

All measurement model results showed acceptable reliability, convergent validity, and indicator quality for the constructs. The majority of outer loadings were above the recommended limit of 0.70, with a range from 0.696 to 0.864. Only the loadings on DCF2 (0.696) and FCS14 (0.699) were slightly below the threshold, but the loadings were very near the threshold, and the reliability and convergent validity were adequate at the construct level, and the items were retained. Cronbach's alpha scores ranged from 0.927 to 0.952, and composite reliability scores ranged from 0.938 to 0.957, well above the minimum of 0.70, thus demonstrating high internal consistency. The average variance extracted values ranged from 0.562 to 0.643, which is above the suggested value of 0.50 and considered adequate convergent validity. CPSE recorded the highest AVE (0.643), followed by ASU (0.629), DSR (0.604), DCF (0.598), and FCS (0.562). Indicator levels' VIF values were between 1.671 and 3.263 and did not present any serious multicollinearity problems, as they are all below the conservative threshold of 5.00. In general, the obtained results showed that the measurement model has achieved indicator reliability, internal consistency, convergent validity, and conditions of no collinearity at an acceptable level, indicating that it was suitable for further evaluation of the structural model and hypothesis testing.

Table 2: Reliability and Validity

Construct	Indicator	Loading	Cronbach's Alpha	CR	AVE	VIF
ASU	ASU1	0.772	0.934	0.944	0.629	2.071
ASU	ASU10	0.783	—	—	—	2.131
ASU	ASU2	0.841	—	—	—	2.748
ASU	ASU3	0.819	—	—	—	2.483
ASU	ASU4	0.781	—	—	—	2.129
ASU	ASU5	0.838	—	—	—	2.704

Construct	Indicator	Loading	Cronbach's Alpha	CR	AVE	VIF
ASU	ASU6	0.778	—	—	—	2.096
ASU	ASU7	0.727	—	—	—	1.882
ASU	ASU8	0.786	—	—	—	2.187
ASU	ASU9	0.803	—	—	—	2.316
CPSE	CPSE1	0.791	0.949	0.956	0.643	2.380
CPSE	CPSE10	0.831	—	—	—	2.718
CPSE	CPSE11	0.787	—	—	—	2.275
CPSE	CPSE12	0.816	—	—	—	2.582
CPSE	CPSE2	0.734	—	—	—	1.930
CPSE	CPSE3	0.778	—	—	—	2.231
CPSE	CPSE4	0.785	—	—	—	2.291
CPSE	CPSE5	0.787	—	—	—	2.294
CPSE	CPSE6	0.777	—	—	—	2.207
CPSE	CPSE7	0.813	—	—	—	2.531
CPSE	CPSE8	0.854	—	—	—	3.047
CPSE	CPSE9	0.864	—	—	—	3.263
DCF	DCF1	0.790	0.952	0.957	0.598	2.373
DCF	DCF10	0.799	—	—	—	2.426
DCF	DCF11	0.764	—	—	—	2.203
DCF	DCF12	0.809	—	—	—	2.569
DCF	DCF13	0.824	—	—	—	2.735
DCF	DCF14	0.742	—	—	—	1.998
DCF	DCF15	0.746	—	—	—	2.071
DCF	DCF2	0.696	—	—	—	1.798
DCF	DCF3	0.720	—	—	—	1.868
DCF	DCF4	0.792	—	—	—	2.388
DCF	DCF5	0.785	—	—	—	2.331
DCF	DCF6	0.763	—	—	—	2.147
DCF	DCF7	0.803	—	—	—	2.532
DCF	DCF8	0.773	—	—	—	2.175
DCF	DCF9	0.786	—	—	—	2.304
DSR	DSR1	0.764	0.927	0.938	0.604	2.033
DSR	DSR10	0.798	—	—	—	2.320
DSR	DSR2	0.779	—	—	—	2.170
DSR	DSR3	0.841	—	—	—	2.727
DSR	DSR4	0.824	—	—	—	2.531
DSR	DSR5	0.762	—	—	—	2.073
DSR	DSR6	0.782	—	—	—	2.180
DSR	DSR7	0.775	—	—	—	1.957
DSR	DSR8	0.737	—	—	—	1.842
DSR	DSR9	0.705	—	—	—	1.671
FCS	FCS1	0.814	0.944	0.951	0.562	2.598
FCS	FCS10	0.740	—	—	—	1.999

Construct	Indicator	Loading	Cronbach's Alpha	CR	AVE	VIF
FCS	FCS11	0.793	—	—	—	2.375
FCS	FCS12	0.722	—	—	—	1.908
FCS	FCS13	0.752	—	—	—	2.060
FCS	FCS14	0.699	—	—	—	1.814
FCS	FCS15	0.804	—	—	—	2.511
FCS	FCS2	0.750	—	—	—	2.036
FCS	FCS3	0.805	—	—	—	2.522
FCS	FCS4	0.757	—	—	—	2.087
FCS	FCS5	0.733	—	—	—	1.945
FCS	FCS6	0.731	—	—	—	1.921
FCS	FCS7	0.730	—	—	—	1.924
FCS	FCS8	0.701	—	—	—	1.792
FCS	FCS9	0.703	—	—	—	1.793

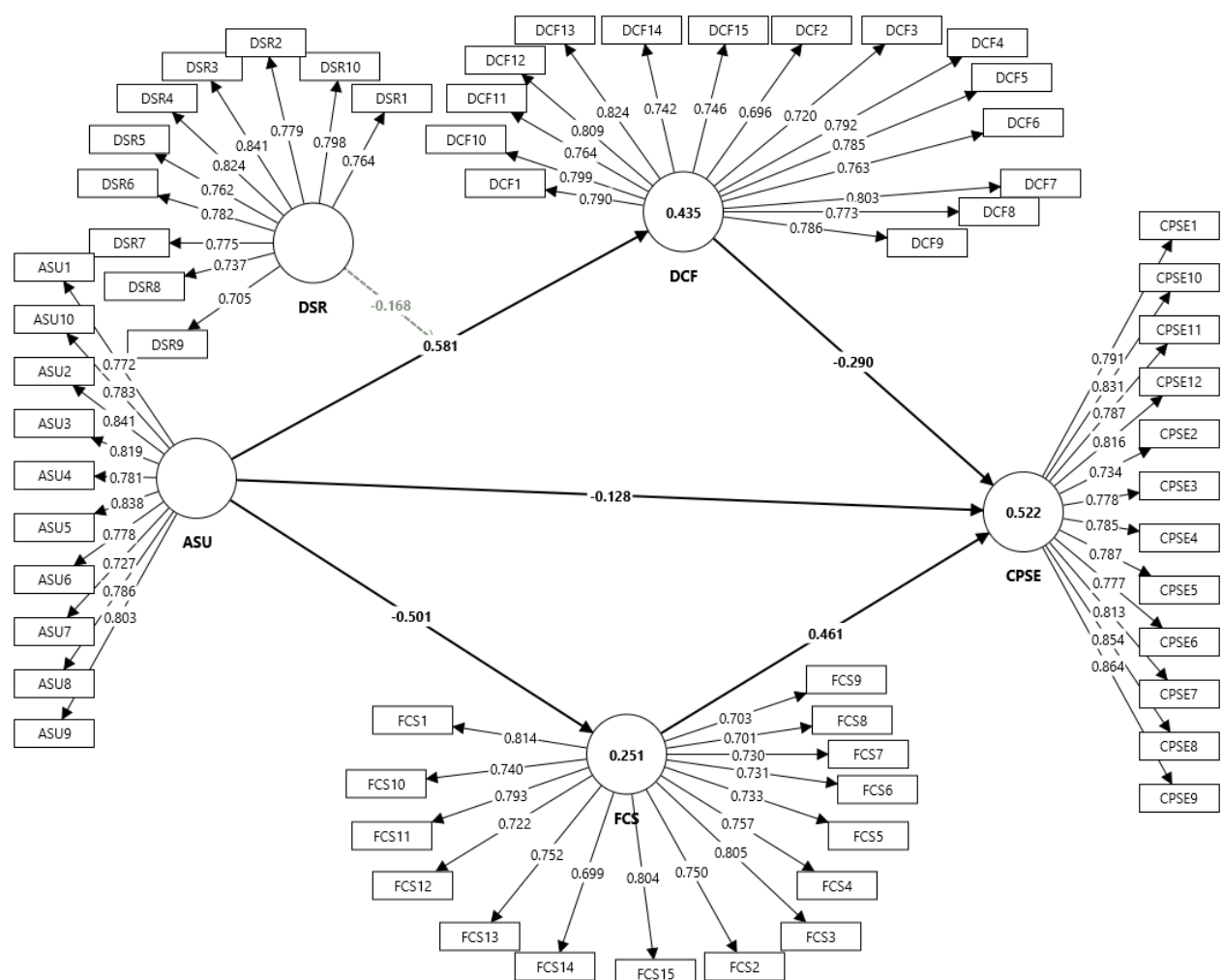


Figure 2: Measurement Model

Discriminant Validity

Satisfactory discriminant validity was confirmed by the HTMT results that showed no more than 6% overlap between all constructs. The ranges were from 0.269 to 0.670, and all values were still below the conservative limit of 0.85. The highest value of

HTMT was found between CPSE and FCS (0.670) and between ASU and DCF (0.658), which suggests that these are moderately correlated, but without signs of threat to construct distinctiveness. Lower values were recorded between DSR and ASU (0.269), DSR and FCS (0.272), and DSR and DCF (0.307). The overall results indicated that each construct was empirically different from the others and hence provided satisfactory discriminant validity for subsequently testing the structural model.

Table 3 HTMT Criteria

Construct	ASU	CPSE	DCF	DSR	FCS
ASU	—	—	—	—	—
CPSE	0.569	—	—	—	—
DCF	0.658	0.576	—	—	—
DSR	0.269	0.398	0.307	—	—
FCS	0.531	0.670	0.413	0.272	—

Structural Model

The structural model results supported all of the hypotheses that were proposed. The results showed that clinical practical skills self-efficacy is negatively and significantly affected by the addictive use of the smartphone ($\beta = -0.128$, $t = 3.099$, $p = 0.002$), confirming Hypothesis H5. Daily cognitive failures were significantly increased by addictive smartphone use ($\beta = 0.581$, $t = 20.712$, $p < 0.001$), confirming H1, and face-to-face communication skills were significantly decreased by addictive smartphone use ($\beta = -0.501$, $t = 15.159$, $p < 0.001$), confirming H2. The regression coefficient for daily cognitive failures and clinical practical skills self-efficacy was found to be significant ($\beta = -0.290$, $t = 7.514$, $p < 0.001$), supporting H3. In contrast, face-to-face communication skills were positively related to clinical practical skills self-efficacy ($\beta = 0.461$, $t = 14.760$, $p < 0.001$), supporting H4. The interaction between digital self-regulation and addictive smartphone use on cognitive failures was significantly negative ($\beta = -0.168$, $t = 5.358$, $p < 0.001$), supporting H8, and reflecting a buffering effect. In addition, both indirect effects were statistically significant. However, the relationship between ASU and CPSE was significantly mediated by face-to-face communication skills ($\beta = -0.231$, $t = 10.640$), supporting H7, and daily cognitive failures were also a significant mediator of ASU and CPSE ($\beta = -0.169$, $t = 7.063$), supporting H6. Overall, all hypothesized direct, mediating, and moderating relationships have been supported statistically.

Table 4: Path coefficient

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
ASU → CPSE	-0.128	-0.126	0.041	3.099	0.002
ASU → DCF	0.581	0.582	0.028	20.712	0.000
ASU → FCS	-0.501	-0.502	0.033	15.159	0.000
DCF → CPSE	-0.290	-0.291	0.039	7.514	0.000
FCS → CPSE	0.461	0.461	0.031	14.760	0.000
DSR × ASU → DCF	-0.168	-0.168	0.031	5.358	0.000

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
ASU → FCS → CPSE	-0.231	-0.232	0.022	10.640	0.000
ASU → DCF → CPSE	-0.169	-0.169	0.024	7.063	0.000

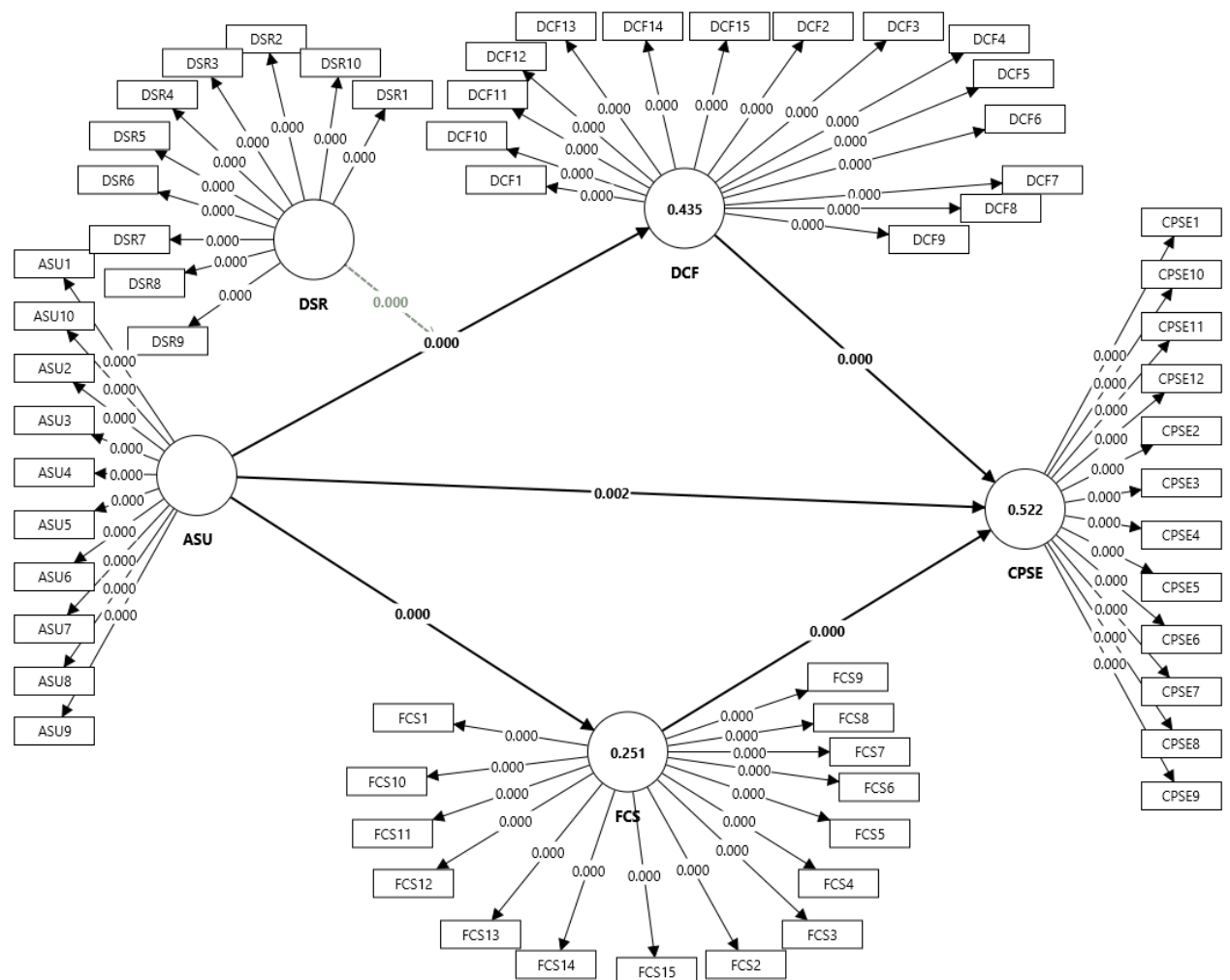


Figure 3: Structural model

Variance and effect size

The goodness of fit of the structural model was satisfactory. The highest R^2 value was for Clinical Practical Skills Self-Efficacy (CPSE) with 52.2% of its variance being accounted for by the predictor constructs. For Daily Cognitive Failures (DCF), the R^2 was 0.435, and 0.251 for Face-to-Face Communication Skills (FCS). Regarding effect sizes, ASU → DCF showed the strongest effect ($f^2 = 0.559$), followed by ASU → FCS (0.335) and FCS → CPSE (0.328). The effects of DCF → CPSE (0.107), ASU → CPSE (0.018) and DSR → DCF (0.039) were comparatively small.

Table 5: R- Square and f-Square

Endogenous Construct	R-square	R-square Adjusted	Structural Path	f-square
CPSE	0.522	0.520	ASU → CPSE	0.018
DCF	0.435	0.432	ASU → DCF	0.559
FCS	0.251	0.250	ASU → FCS	0.335

Endogenous Construct	R-square	R-square Adjusted	Structural Path	f-square
			DCF → CPSE	0.107
			DSR → DCF	0.039
			FCS → CPSE	0.328

Predictive Analysis

The results of the CVPAT confirmed good predictive ability of the proposed structural model. For all endogenous constructs, the average loss difference was negative, with PLS loss lower than the indicator-average benchmark loss. The greatest predictive improvement by DCF was with a difference of -0.739, followed by CPSE with -0.604 and FCS with -0.422. The differences between all of the groups were significant at the level of $p < 0.001$ and ranged between $t = 6.424$ and $t = 8.974$. The overall model had a significant predictive advantage with a mean loss difference of -0.587 and $t = 10.046$. The predictions from these tests indicate that the model has some out-of-sample predictive ability.

Table 6: CVPAT

Construct	PLS loss	IA loss	Average loss difference	t value	p value
CPSE	2.474	3.078	-0.604	7.763	0.000
DCF	2.177	2.917	-0.739	8.974	0.000
FCS	2.622	3.044	-0.422	6.424	0.000
Overall	2.421	3.008	-0.587	10.046	0.000

Discussion

The results showed that addictive smartphone use had direct and indirect negative effects on the clinical practical skills self-efficacy of medical students in Pakistan and that these effects were mediated by cognitive and interpersonal processes. The negative association with cognitive failures ($\beta = 0.581$) and reduction in face-to-face communication skills ($\beta = -0.501$) was seen, which helped support the I-PACE hypothesis that problematic technology use leads to dysfunctional outcomes due to cognitive control impairments and maladaptive behavior (Brand et al., 2019). The findings of the positive correlations among smartphone addiction and cognitive failures aligned with previous studies that found that excessive smartphone use was associated with mind wandering, attentional lapses, and poor self-regulation (Al-Abyadh et al., 2024; Li et al., 2025). Similarly, the negative impact on communication skills was consistent with studies showing that the negative aspects of problematic smartphone use negatively affect interpersonal communication skills among health-profession students (Celikkalp et al., 2020; Başgöl & Rüzgar, 2025). The daily cognitive failures were found to have a negative impact on clinical practical skills self-efficacy, while communication skills had a positive impact, showing that clinical confidence is related to both cognitive function and interpersonal skills. Importantly, both mediating effects were significant, suggesting that clinical confidence was weakened by two pathways: smartphone addiction and both addiction and clinical depression. Digital self-regulation was a significant negative effect on the ASU–DCF relationship, which was found to be a protective factor. The model accounted for 52.2% of the CPSE variance, with good out-of-sample predictive power, thus increasing the robustness of the proposed framework.

Theoretical Implications

The study expanded on the I-PACE model by showing that smartphone addiction was not only on psychological or academic aspects but on the practice-oriented clinical

ability as well. The proposed framework introduced two parallel mediators: everyday cognitive failures and interpersonal communication skills, as a way to explain how addictive smartphone use led to a diminished sense of clinical practical skills self-efficacy. This integration was an extension of I-PACE's cognitive scope, which now included an interpersonal pathway pertinent to medical education. The results also confirmed and extended self-efficacy theory and demonstrated that cognitive stability and interpersonal functioning, in addition to mastery experiences, influenced clinical confidence. Digital self-regulation also served as a boundary condition by reducing the negative relationship between ASU and DCF, and helped to elucidate when the use of the smartphone became less cognitively disruptive. Overall, the model linked behavioral addiction to cognitive failure, communication competence, self-regulation, and clinical self-efficacy in a unified explanatory framework, which was more useful for the study of digital behaviors and professional competence in medical education.

Practical Implications

The results indicated practical measures that could be taken by medical universities in Pakistan. Smartphones and digital wellbeing should not just be viewed as a disciplinary matter – it must be built into the structure of clinical training. Students could be educated in the management of notifications, the scheduling of a phone-free study time, how to identify compulsive checking, and how to differentiate between learning and addiction to the smartphone. Workshops could teach students to handle notifications, how to set the time aside to use the phone for learning and not addiction, how to spot compulsive checking, and how to separate educational and addictive smartphone use. To minimize forgetfulness and task disruption, clinical teaching should incorporate attention-management strategies, procedural checklists, rehearsal with simulation and debriefing, as these are known to increase clinical practical skills self-efficacy in cases of cognitive failure. The positive impact of face-to-face communication skills also pointed to the need for supervised patient interaction, role play, bedside communication practice and feedback on listening and responsiveness. Tools to assess problematic smartphone use may be integrated into services for students to identify at an early stage students who are likely to have problem use. Digital self-regulation training should be given special attention because it diffused the negative impact of problem smartphone usage on cognitive failures and could be used as a training method to help students regulate their attention in difficult clinical learning.

Managerial Implications

For medical-university administrators, the findings served as “direction” for making evidence-based digital-use policies without broad bans. Guidelines for smartphone usage should be clearly defined for lectures, skills laboratories, bedside teaching and clinical rounds, yet leave space for usage where it is deemed essential for medical learning. Digital self-regulation and communication-skills programs ought to be implemented in student-affairs units, clinical departments, and counselling services together for students with compulsive phone-use patterns. Faculty should be instructed to set an example for appropriate smartphone practice and plan sessions where the smartphone is required to be used, patients are engaged, and "hands-on" is required. Monitoring of smartphone use should be based on functional impairment, not on screen time, due to the strong association between addictive smartphone use and cognitive failures and impaired communication skills. Periodic surveys on smartphone addiction, cognitive challenges, and communication skills, conducted anonymously at the university level, could inform interventions based on the data collected. In addition, administrators should make digital professionalism a part of competency frameworks, making it part of the process of preparing for safe, attentive, patient-centered practice.

Limitations and Recommendations

There are a number of caveats to be noted. First, the cross-sectional design precluded the inference of causes, despite the theoretical specification and high predictive power of the structural model. To examine if there is a temporal precedence of addictive smartphone use leading to changes in cognitive failures, communication skills, and clinical self-efficacy, future studies should use longitudinal or time-lagged designs. Second, the study used self-report measures that could be susceptible to social desirability and common-method bias. Future studies should use a questionnaire along with an objective log of smartphone use, observation of communication behavior, and faculty assessment of clinical competence. Third, the findings are only representative of the third, fourth, and final year MBBS students, and should be interpreted with caution in other groups of learners like pre-clinical students, dental students, nurses, or other health-profession students. Comparative research in different disciplines and provinces is recommended. Finally, clinical practical skills SE was measured as perceived capabilities, not actual competence. Further research should assess if the proposed mechanisms predict OSCE scores or real examination results and if digital self-regulation interventions can be experimented with to assess their effects.

Conclusion

The study findings showed that addictive smartphone use was an important behavioral risk for the practical development of medical students in Pakistan. It could not only lead to teacher distraction in the classroom, but also have a direct negative impact on clinical practical skills self-efficacy and an indirect effect through daily cognitive failure and diminished face-to-face communication skills. The results confirmed a dual-mechanism interpretation, where addictive smartphone use led to a reduction of cognitive resources and interpersonal skills for optimal clinical learning. Cognitive failures were associated with an increase with addictive use, while clinical confidence was associated with a decrease. Communication skills were associated with increasing clinical practical skills self-efficacy, while cognitive failures were associated with decreasing clinical practical skills self-efficacy. The negative relationship between the addictive use of the smartphone and cognitive failures was moderated by digital self-regulation, which demonstrated its protective role. The results of the model showed that it accounted for a significant amount of the variance in clinical practical skills self-efficacy and had good predictive abilities, considering the results of CVPAT. In general, medical universities must move beyond the simplistic approach of merely concentrating on screen time and investigate the cognitive, interpersonal, and functional impacts of addictive use of the smartphone, as well as promoting responsible, self-regulated use of the technology.

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