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Mindfulness and Social Media: Impact on Reflective Thinking and Cognitive Engagement in Undergraduate Students

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Research Article

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Abstract

Background/purpose. This study explores how mindfulness (MIN), social media use (SMU), reflective thinking (RT), and cognitive engagement (CE) interact among undergraduate students.

Materials/methods. The descriptive approach combined with Structural Equation Modelling (SEM), using Smart PLS 4, was applied to analyze the complex relationships between MIN, SMU, RT, and CE among undergraduate students. This approach ensured measurement reliability and validity through a structured two-stage analysis.

Results. Findings confirm that MIN and SMU positively impact RT and CE, with RT acting as a key mediator. MIN fosters awareness, self-control, and resilience, while strategic SMU promotes collaboration and engagement. The results confirm all hypotheses, highlighting RT's importance in linking MIN and SMU to CE.

Conclusion. This study examines the transformative role of MIN in promoting deeper CE and enables students to reflect on their learning experiences critically. The findings stress the crucial role intentional SMU plays in optimizing educational outcomes while minimizing potential distractions. This research provides insights that offer practical strategies to improve academic performance, improve students' mental well-being, and promote MIN and social media integration into undergraduate education.

1. Introduction

With the growing integration of digital technologies in higher education comes a pressing urgency to understand how MIN affects RT and CE and how these aspects influence students' academic involvement and learning outcomes. Mindfulness-informed pedagogies have been shown to enhance students' self-awareness, focus, and engagement in learning environments (Ren, 2023). Studies have indicated that controlled social media integration can enhance student engagement; however, achieving deep criticality and RT remains a challenge (Sakr, 2019). This highlights the need to explore MIN and RT's effects on academic engagement, as they form cognitive and emotional foundations necessary for student success (Rogowska, Kuśnierz, & Pavlova, 2020; Phan, 2009; Mezirow, 1997).

The university stage is a crucial period for shaping students' personalities and career plans. One important topic that reflects students' immersion in various activities is academic engagement, resulting in meaningful involvement. This requires both personal factors, such as motivation, goals, tendencies, and abilities, as well as external support from the surrounding educational environment (Abdeen, 2019). This combination of individual traits and external support is vital for student success. Academic engagement involves deep participation in learning; therefore, RT is essential for fostering critical analysis, problem-solving, and meaningful educational experiences, all of which heighten engagement (Larrivee, 2008, Kuhn, 1999).

RT is a key aspect of critical thinking that focuses on analyzing and evaluating past experiences (Chamdani et al., 2022). Over the past decade, scholars have emphasized its growing importance in 21st-century education (Willingham, 2007). RT enhances problem-solving in both personal and professional contexts while strengthening the connection between prior knowledge and new obstacles (Chen, Hwang, & Chang, 2019). Academic engagement thrives on cognitive depth and critical evaluation. Thus, RT plays a key role in helping students reflect on their learning and make well-informed academic decisions. (Rolheiser, Bower, & Stevahn, 2000).

MIN is broadly defined as focusing attention on the present moment while observing internal and external events without judgment (Mortimore, 2017). Research has suggested that practicing MIN promotes personal growth by helping students embrace their emotions, thoughts, and experiences, rather than avoid them (Morgan & Katz, 2021). RT promotes critical analysis of past experiences, whereas MIN enhances students' present-moment awareness, establishing a cognitive balance that increases engagement and supports adaptive learning. This transformative impact stems from its ability to enhance self-awareness and emotional regulation, directly impacting learning processes and outcomes. (Immordino-Yang & Damasio, 2007)

In recent years, educational and psychological research has highlighted factors that improve educational outcomes and elevate students' mental health. Studies have indicated that MIN greatly improves attention and concentration, supporting cognitive functions as well as students' mental and physical well-being (Abdelhamid, 2021; Tarrasch, 2018). Wang, Xu, and Qin (2019) have emphasized the need for students to practice MIN, as their tasks rely heavily on mental engagement. By focusing, observing, and reflecting on their experiences, students can consciously navigate daily challenges. MIN enhances attentional control and emotional regulation; its effects extend to CE and academic performance, reinforcing its role in optimizing student success. Thus, incorporating MIN into academic settings is important to optimize engagement and long-term success.

Previous research has shown that MIN and RT improve cognitive processes and learning outcomes. For instance, a study on Iraqi EFL learners have revealed that both MIN and RT improved reading comprehension, while reading anxiety hindered their performance (Alsharhani et al., 2023). Furthermore, MIN has been proven to enhance the learning experience, motivation, and autonomy in ICALL environments, as seen in a study of 398 Iranian EFL learners (Namaziandost & Rezai, 2024).

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These findings reinforce the harmonious connection between MIN and RT, demonstrating their role in promoting greater CE and academic growth.

SMU has become a central part of students' daily lives in the digital age, forming a routine of swiping, scrolling, and navigating platforms (Lupinacci, 2021). While it provides networking and communication opportunities, SMU also poses challenges such as digital distraction and overdependence. Furthermore, the pandemic has intensified reliance on social media, particularly among university students, as it became a vital means of communication during quarantine (García-Penalvo, 2021). This increased reliance highlights the need for greater awareness during SMU.

The relationship between MIN and SMU is an emerging area of research. Recent studies have revealed a positive link between MIN and intentional SMU for cognitive and entertainment purposes (Al-Jasas, 2022). This suggests that MIN could regulate students' SMU behaviors, ensuring that digital interactions improve rather than hinder CE and RT. By fostering awareness and self-regulation, MIN may help students balance the benefits of SMU while mitigating its negative effects. It is therefore necessary to examine how MIN and RT contribute to students' CE, particularly in the presence of digital distractions such as SMU.

Recent educational and psychological research has highlighted factors that enhance learning outcomes and support students' cognitive and emotional development. MIN has emerged as a key contributor, improving attention, emotional regulation, and CE to meet the demands of modern education. Closely linked to MIN, RT helps students critically analyze experiences, promoting deeper learning and better decision-making. As SMU continues to shape students' cognitive and social behaviors, understanding its interactions with MIN and RT is essential for fostering academic engagement and long-term success. Exploring these interactions allows researchers to understand how digital habits impact learning processes. This study addresses a critical gap by exploring these relationships among undergraduate students.

To address this gap, the study poses the question: "What are the interactions and impacts of MIN, SMU, RT, and CE among undergraduate students?" This question directly addresses the discussed challenges by investigating how MIN and SMU influence RT and CE. This helps provide insights into effective digital learning strategies. Examining these relationships provides valuable insights into how MIN and SMU influence cognitive and reflective processes. The following hypotheses were constructed to analyze how MIN, SMU, RT, and CE interact with one another. These aim to measure the impact of MIN and SMU on RT and CE, as well as RT's mediating role. Understanding these dynamics is essential for developing strategies to enhance students' cognitive and reflective abilities in the digital age. The hypotheses are as follows:

H1: There is a significant positive effect of MIN on RT.

H2: There is a significant positive effect of MIN on CE.

H3: There is a significant positive effect of SMU on RT.

H4: There is a significant positive effect of SMU on CE.

H5: There is a significant positive effect of RT on CE.

H6: There is a significant mediation effect of RT in the relationship between MIN and CE.

H7: There is a significant mediation effect of RT in the relationship between SMU and CE.

These hypotheses examine how MIN and SMU impact RT and CE among undergraduate students. The findings will offer valuable insights into these relationships, laying the groundwork for strategies that enhance MIN, strengthen RT, and promote CE in educational settings.

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2. Literature Review

2.1. Reflective Thinking (RT)

Over the past decade, RT has gained significant attention, with scholars emphasizing its importance in 21st-century education (Willingham, 2007). It involves an intellectual practice where students establish connections between prior knowledge and new experiences. RT also enhances the ability to process information and justify decisions (Chen, Hwang, & Chang, 2019).

It is essential to explore RT's role in cognitive processes and learning strategies to further grasp its significance in education. RT enables learners to reflect on and evaluate their problem-solving strategies, helping them reach their goals (Akpur, 2020; Orakcı, 2021). It allows students to analyze situations critically, persistently, and systematically, and to challenge assumptions by grounding them in evidence (Ozudogru, 2021). RT, recognized as a key higher-order thinking skill, incorporates critical thinking, logical reasoning, metacognition, and creativity (Setiawan et al., 2021; Aldahmash, Alshalhoub, & Naji, 2021).

RT involves self-reflection or retrospective analysis, and an awareness of learning processes. It also promotes regular self-improvement and self-confidence in assessing personal achievements (Chen, Hwang, & Chang, 2019). The reflective nature of RT provides a foundation for effective problem-solving; it enables students to refine their thought processes and approach challenges with profound clarity. Thus, RT enhances self-awareness and enables strategic decision-making in complex situations.

In educational settings, RT promotes learning during complex problem-solving situations (Akpur, 2020; Orakcı, 2021). It promotes both physical and mental engagement to tackle personal and professional challenges, enabling students to reassess their approaches and refine their strategies for improved results (Lee & Gyogi, 2016). The relationship between RT and MIN is essential for optimizing CE and emotional regulation. Studies highlight a strong link between RT, MIN, and higher CE. For instance, MIN interventions have been proven to enhance RT by fostering greater self-awareness and minimizing cognitive distractions (Ghanizadeh & Ghonsooly, 2022).

Therefore, MIN serves as a complementary practice that enhances RT's benefits. RT plays a vital role in academic development. Research involving Saudi Arabian EFL learners revealed that RT, combined with self-evaluation, significantly improved MIN, resilience, and academic development. The study highlighted the similar benefits of RT and self-evaluation, demonstrating their role in promoting academic success and psychological resilience in students (Al-Rashidi & Aberash, 2024). Further, MIN practices allow individuals to reflect on past and present experiences, enhancing their RT through a profound understanding of these moments (Kabat-Zinn, 2001).

RT is thus considered a vital educational tool that promotes higher-order thinking, critical analysis, and problem-solving skills. Integrating MIN and RT-based strategies into education enables students to develop more comprehensive approaches to learning, ones that that involve cognitive adaptability and emotional intelligence. Incorporating RT-based strategies and MIN practices into curricula can improve academic and cognitive outcomes, anticipating students for lifelong learning and adaptability in a dynamic world. RT empowers learners to tackle complex challenges through confidently structured problem-solving methods (Setiawan et al., 2021; Aldahmash, Alshalhoub, & Naji, 2021) while refining their approaches to achieve goals effectively (Akpur, 2020; Orakcı, 2021).

2.2. Mindfulness

MIN is the intentional, non-judgmental awareness of one's current sensory and cognitive experiences (Kabat-Zinn, 2003). It requires focusing on internal and external events without judgement, heightening present-moment awareness (Kabat-Zinn, 2003). This definition illustrates

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MIN as a practice that promotes personal growth by encouraging individuals to accept their thoughts, emotions, and experiences, including negative ones, rather than avoid them (Morgan & Katz, 2021). Further, mindfulness promotes self-awareness, minimizes cognitive distractions (Ghanizadeh & Ghonsooly, 2022), and develops a reflective mindset that reinforces deeper learning (Kabat-Zinn, 2001; Ghanizadeh & Ghonsooly, 2022).

The growing use of MIN techniques in education reflects their transformative impact. MIN enhances awareness of the learning process, better prepares students for learning experiences, and provides a comprehensive approach to learning, integrating both thoughts and emotions (Kuru Gönen, 2022). Studies indicate that mindful students showcase improved attention, higher academic performance, and greater achievement, attributed to their heightened focus and self-awareness (David & Sheth, 2009).

MIN techniques have recently attracted significant attention, especially in education. Research indicates that mindfulness not only improves mental and physical health but also strengthens resilience and cognitive abilities for both students and educators (Fallah, 2017; Varlık & Varlık, 2024). Mindfulness also notably reduces the negative effects of excessive social media use. It's been associated with enhanced attentional focus, moderating symptoms linked to overuse. (Throuvala et al., 2020). Additionally, mindfulness practices have proven highly effective in boosting RT, with research demonstrating they explain up to 50% of the variance in RT capabilities (Ghanizadeh & Ghonsooly, 2022).

MIN has various educational applications, with practices like guided meditation and mindfulness exercises demonstrating moderate positive effects on students' psychological and social well-being, including greater optimism, resilience, and lower anxiety and depression (Roeser et al., 2023). Further, incorporating MIN practices into teaching enhances academic engagement and learning outcomes as it helps students remain present and focused, supporting their educational progress (Zeilhofer & Sasao, 2022). Moreover, mindfulness has been linked to enhanced teaching commitment when mediated by readiness for change, highlighting its indirect influence in educational settings (Yeap & Thien, 2021).

MIN has become essential in education, improving focus, emotional stability, and academic achievement for learners and educators. Integrating mindfulness into education can help institutions build a more supportive and productive learning environment. As digital technologies reshape modern learning, MIN helps regulate online behaviors, including social media use, by enhancing self-awareness and reducing digital distractions (Li et al., 2024).

2.3. Social Media

In the digital era, social media has become an essential tool for connecting people. Simultaneously, it enables the imitation of celebrity culture and the creation of a media-driven world, centered around individuals (Macit, Macit, & Güngör, 2018). It provides students and educators with diverse communication channels, opportunities for knowledge-sharing, and the ability to build collaborative learning communities (Dron & Anderson, 2014). Social media platforms can also boost student engagement and expand communication channels through participatory media practices (Muringani & Noll, 2021).

Excessive social media use can result in various effects including increased isolation, a false sense of connection with online users, and addictive practices (Baumer, 2013; Moore & Craciun, 2021). Studies indicate that over-dependence on social media can lead to dilemmas, intensifying feelings of isolation despite the illusion of social involvement (Baumer, 2013). This emphasizes the need for self-regulation strategies, with MIN as a mitigator, helping students balance their online engagement and allowing them to focus on academic and personal well-being. (Zhang & Zou, 2024)

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The COVID-19 pandemic led to a significant rise in social media use, especially among university students, as it became a primary tool for communication and support during social isolation (García-Penalvo, 2021). Social media also helped compensate for the absence of real-world connections, providing informational and emotional support to individuals, particularly those facing illness (Ytre-Arne, 2016).

Despite their drawbacks, social media platforms are often framed as spaces for networking and communication, providing a sense of social and informational support (Kross et al., 2021). Research suggests that MIN effectively counters the negative effects of excessive social media use. It has been associated with mediating symptoms of overuse, as it develops a state of heightened attention and awareness (Throuvala et al., 2020). Studies also reveal a positive relationship between SMU and mindfulness in specific contexts, such as the pandemic, where they facilitated knowledge acquisition and entertainment (Al-Jasas, 2022).

According to studies, incorporating MIN practices can help reduce the harmful effects of social media (Throuvala et al., 2020; Baumer, 2013) while also repurposing it as a tool to enhance RT (Ghanizadeh & Ghonsooly, 2022) and academic engagement (Bakosh et al., 2018; Roeser et al., 2023). A meta-analysis of 14 studies found that lower MIN is associated with higher problematic social media use (Meynadier et al., 2024). As a protective factor, MIN helps reduce overthinking, alleviating mental distress from social media exposure while promoting mental health and CE (Hong et al., 2021).

In summary, social media presents both opportunities and challenges, with its impact depending on how it is utilized. While it can support academic engagement and facilitate communication, excessive use calls for intentional strategies, such as MIN integration, to reduce its negative effects and optimize its potential (Widdicks, 2020; Muringani & Noll, 2021).

2.4. Cognitive Engagement (CE)

CE is a complex, multidimensional concept shaped by psychological, social, and cultural influences. It represents the extent of students' mental investment in comprehending and mastering academic material (Fredricks, 2011; Lester, 2013; Zepke & Leach, 2010). CE is defined by dynamic, adaptable, constructive, goal-oriented, and sustained interactions with both physical and social environments (Sadoughi & Hejazi, 2023).

Learning motivation serves as a central aspect of CE driving students to persist through academic challenges and engage in deep information processing through critical thinking and self-regulation. These procedures enable active knowledge construction and content comprehension (Fredricks, 2011; Bar, 2009; Huaisheng et al., 2019). RT is crucial for advancing CE as it helps students link prior knowledge to new problems, evaluate problem-solving strategies, and anticipate potential outcomes (Akpur, 2020; Orakcı, 2021).

Higher-order thinking skills, including critical thinking, logical reasoning, metacognition, and creative thinking, are closely tied to CE and play a vital role in teaching and learning. These skills impact cognitive, emotional, and psychomotor domains, ultimately improving overall academic performance (Qasrawi & Beni Abdelrahman, 2020). Students who engage in RT are more capable of problem-solving, decision-making, recalling structured knowledge, and analyzing texts, significantly enhancing their CE (Kablan & Gunen, 2021).

The learning environment is a key factor in promoting CE. Academic engagement is driven by students' inherent motivation and personal goals. Furthermore, it is shaped by external support from the educational setting, including opportunities to participate in purposeful activities.

Research highlights the connection between MIN and CE. MIN applications focus on the present moment and non-judgmental acceptance, improve focus, emotional regulation, and stress

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management. Such assets are particularly valuable in academic settings, as they support better academic performance and student engagement (Roeser et al., 2023; Bakosh et al., 2018). Studies show that MIN mediates school attachment and academic engagement, strengthening students' dedication to their educational goals (Bakosh et al., 2018).

Mindfulness-based interventions effectively reduce overthinking, directly enhancing CE and RT, especially in education. These interventions help undergraduate students navigate cognitive and emotional challenges, promoting academic success and mental health amid rising social media use (Mao et al., 2023).

Thus, CE is fundamental to effective learning, relying on active participation, RT, and a supportive educational environment. Educators can strengthen students' CE by promoting higher-order thinking skills and incorporating MIN practices, leading to greater academic achievement and personal development.

3. Methodology

This adopted uses a descriptive approach alongside SEM to explore the relationships among undergraduate students between MIN, SMU, RT, and CE. The descriptive approach provided detailed insights into these constructs and their interconnections within the target population, offering a better understanding of behavioral patterns before testing their relationships. Meanwhile, SEM enabled a comprehensive analysis of their complex relationships, validating the gathered descriptive insights. The study specifically examined MIN practices, SMU patterns, RT processes, and CE levels in academic settings.

SEM was applied for data analysis using (Smart-PLS4) to implement the descriptive findings within a statistical framework. SEM was implemented in two stages. The first stage involved Standard Model Analysis, assessing the measurement model's reliability and validity. The second stage, Structural Model Analysis, examined the relationships between constructs as hypothesized. Integrating descriptive and statistical methods ensured a more comprehensive examination, as SEM quantified relationships while refining the theoretical constructs derived from the descriptive analysis (Kline, 2016). SEM was chosen for its ability to estimate complex correlations between manifest and latent constructs, providing a comprehensive evaluation of the studied relationships.

Given the methodological complexity of SEM, a well-defined, representative sample was essential to ensure sound statistical modeling. The study population comprised undergraduate students from the University, selected from both humanities and science disciplines. A random sample was drawn from two key groups: General Chemistry (350 students) and the English Department (150 students), establishing a diverse and representative sample across various academic fields. This ensured that the measured relationships in various academic contexts increase the generalizability of the SEM results. Notably, the General Chemistry course included students from various fields such as Chemistry, Physics, Biology, Forensic Science, Mathematics, Pharmacy, Medicine, Dentistry, Dental Technology, and Biomedical Engineering, further enhancing sample representation. The total study population is 500 students, with a final sample of 338 respondents. These were 240 students from General Chemistry and 98 from the English Department. The survey was distributed electronically to facilitate broad accessibility, and the questionnaire items were piloted, tested, and refined to ensure reliability and validity.

The sample included two distinct academic disciplines to ensure diversity. However, the numerical imbalance between the General Chemistry group (240) and the English Department group (98) may have disturbed model balance. This issue was addressed during the model fit evaluation using indicators such as R^2, Q^2, and f^2, which indicated no significant impact on the structural model's

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stability. While this limitation was acknowledged, future research is encouraged to adopt more balanced group sizes to enhance generalizability.

To ensure that the questionnaire accurately captured the relationships examined through SEM, it was designed around four main dimensions: MIN, SMU, RT, and CE. Each construct was assessed using specific items adapted from validated scales in previous research to ensure theoretical alignment and measurement reliability. MIN items were based on Brown & Ryan's (2003) framework, SMU items were based on the work of Gupta & Bashir (2018), RT items were followed by Kember et al. (2000), and CE items were adapted from Cebrián Cifuentes and Guerrero Valverde (2024). Aligning measurement tools with established theoretical frameworks ensured that the data accurately represented the constructs being analyzed.

These dimensions were systematically applied to assess the relationships between MIN, SMU, RT, and CE among undergraduate students. Statistical tests were conducted to confirm the reliability and consistency of these measurements. The study ensured construct measurement consistency, providing a reliable analytical foundation. Composite reliability and factor loadings were employed to evaluate the measurement model's internal consistency and construct validity, ensuring accuracy and relevance in relation to the study hypotheses.

The high composite reliability values (>0.70) implied that the constructs (MIN, SMU, RT, and CE) are measured consistently across different items. This level of reliability suggests that the constructs were stable and dependable, reinforcing the validity of the measurement model and providing a solid foundation for further analysis.

Factor analysis evaluated the variation among relevant variables and factors. Factor loading measured the correlation between a construct and a specific factor, indicating how much variance in the factor was explained by the construct. In SEM, a factor had to capture sufficient variance from an observed construct to be considered significant. A factor loading of 0.5 or higher was generally considered acceptable (Hair et al., 2016), indicating a strong relationship between the factor and its variable, which confirmed the factor's validity in capturing the intended constructs.

4. Results and Discussion

This section presents the statistical analysis results, including factor loadings, composite reliability, and the relationships among key constructs. The findings provide insights into the interactions and effects of MIN, SMU, RT, and CE on undergraduate students.

Table 1 shows that all constructs exceed the 0.50 threshold, aligning with Hair et al.'s (2016) criteria. The measurement model was assessed based on reliability and validity metrics to further validate construct quality.

Table 1. Factor loadings for different constructs

Constructs	Codes	Mean	SD	Factor Loading	VIF	α	CR	AVE
MIN	MIN.1	4.290	0.702	0.698	2.047	0.95	0.95	0.58
	MIN.2	3.982	0.841	0.786	3.468			
	MIN.3	3.988	0.816	0.859	4.859			
	MIN.4	4.083	0.848	0.699	2.355			
	MIN.5	3.923	0.886	0.770	3.073			
	MIN.6	4.592	0.694	0.528	1.870			

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	MIN.7	4.166	0.799	0.754	2.649			
	MIN.8	4.071	0.813	0.837	3.222			
	MIN.9	4.450	0.779	0.661	2.487			
	MIN.10	4.290	0.782	0.727	2.920			
	MIN.11	4.101	0.864	0.805	3.475			
	MIN.12	3.994	0.929	0.798	4.258			
	MIN.13	3.964	0.801	0.897	4.981			
	MIN.14	4.231	0.787	0.760	3.111			
	MIN.15	4.107	0.809	0.755	2.871			
SMU						0.95	0.95	0.51
	SMUS.1	4.053	0.984	0.807	2.615			
	SMUS.2	4.331	0.670	0.789	3.552			
SMUS	SMUS.3	4.018	0.848	0.871	3.106	0.87	0.91	0.67
	SMUS.4	3.562	1.095	0.888	3.663			
	SMUS.5	3.935	0.958	0.719	3.096			
	SMUI.6	3.840	0.984	0.780	3.939			
	SMUI.7	4.402	0.658	0.759	4.447			
SMUI	SMUI.8	4.314	0.757	0.709	2.783	0.81	0.87	0.56
	SMUI.9	4.538	0.535	0.658	2.321			
	SMUI.10	3.917	0.929	0.836	4.248			
	SMUN.11	4.367	0.642	0.826	3.087			
	SMUN.12	3.959	0.934	0.820	3.974			
SMUN	SMUN.13	4.012	0.859	0.774	4.153	0.88	0.91	0.68
	SMUN.14	3.882	0.969	0.883	4.893			
	SMUN.15	4.231	0.824	0.823	3.537			
	SMUE.16	4.166	0.729	0.839	2.953			
	SMUE.17	4.189	0.715	0.832	4.498			
SMUE	SMUE.18	4.491	0.589	0.777	2.841	0.85	0.9	0.63
	SMUE.19	4.320	0.727	0.723	2.913			
	SMUE.20	4.118	0.722	0.800	3.726			
RT						0.94	0.94	0.52
	RTW.1	3.686	0.901	0.901	4.268			
	RTW.2	3.852	0.886	0.886	3.691			
RTW	RTW.3	3.746	0.893	0.893	4.108	0.91	0.93	0.78
	RTW.4	3.905	0.856	0.856	3.426			

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RTU	RTU.5	4.396	0.807	0.807	2.914	0.82	0.88	0.65
	RTU.6	4.568	0.834	0.834	2.002			
	RTU.7	4.438	0.815	0.594	2.393			
	RTU.8	4.249	0.765	0.815	1.306			
RTR	RTR.9	4.254	0.861	0.765	4.602	0.87	0.91	0.72
	RTR.10	4.331	0.884	0.861	2.847			
	RTR.11	4.402	0.861	0.884	4.827			
	RTR.12	4.396	0.797	0.861	1.801			
RTC	RTC.13	3.994	0.843	0.797	3.642	0.88	0.92	0.74
	RTC.14	3.888	0.893	0.843	2.665			
	RTC.15	3.935	0.874	0.893	3.513			
	RTC.16	4.201	0.822	0.874	2.078			
CE	CE.1	4.160	0.621	0.866	3.639	0.93	0.94	0.61
	CE.2	4.254	0.627	0.766	2.708			
	CE.3	4.118	0.722	0.773	2.463			
	CE.4	4.195	0.726	0.797	2.297			
	CE.5	4.272	0.575	0.829	2.863			
	CE.6	4.219	0.602	0.840	3.095			
	CE.7	4.320	0.667	0.673	1.645			
	CE.8	4.201	0.660	0.779	2.449			
	CE.9	4.219	0.727	0.749	2.487			
	CE.10	4.107	0.802	0.731	2.270			

Table 2 presents the factor loadings for MIN, SMU, RT, and CE, with most exceeding the recommended 0.60 threshold. All loadings surpassed 0.50, demonstrating strong reliability and confirming that the items effectively represent their respective constructs. These high loadings imply strong associations between observed variables and latent constructs, ensuring precise measurement. It is worth noting that a few items, such as MIN.6 = 0.528, fell just below the 0.60 threshold. Despite posing a minor limitation, these items were retained due to their theoretical relevance and acceptable contribution to the overall model fit.

These findings support the study's primary objective, confirming that the constructs are measured accurately and reliably. This enables the study to explore relationships among the constructs and derive meaningful insights, reinforcing the validity of the proposed framework for educational and structural analysis.

4.1. Construct Reliability and Validity

Reliability and validity were evaluated using Cronbach's Alpha (α), Composite Reliability (CR), and Average Variance Extracted (AVE). Cronbach's Alpha ranged from 0.81 to 0.95, while CR values spanned 0.87 to 0.95, both exceeding the 0.70 threshold. These results confirmed strong internal consistency and demonstrate how the scale items effectively represent their respective constructs.

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Additionally, AVE values ranged from 0.51 to 0.78, surpassing the 0.50 threshold recommended by Fornell and Larcker (1981). This indicates that the constructs account for more than 50% of the variance in their indicators, confirming strong convergent validity. Constructs such as CR (α = 0.88, CR = 0.92, AVE = 0.74), CI (α = 0.93, CR = 0.94, AVE = 0.61), and RTR (α = 0.87, CR = 0.91, AVE = 0.72) demonstrated particularly high reliability and validity. Overall, the results reinforce the accuracy of the measurement model, ensuring its suitability for further analysis. However, minor deviations, such as isolated lower factor loadings, may require further research.

4.2. Discriminant Validity

Discriminant validity confirms that the model constructs are distinct from one another and measure unique theoretical concepts. This study assessed discriminant validity using the Fornell-Larcker criterion (Campbell & Fiske, 1959), as presented in Table 3. This method evaluates the correlation strength between constructs to ensure they are conceptually separate.

The findings demonstrated that all constructs met the Fornell-Larcker criterion, as their self-correlation values were consistently higher than their correlations with other constructs. For instance, CE had a self-correlation of 0.782, surpassing its correlations with SMUI (0.777) and RTW (0.758). Likewise, RTW's self-correlation (0.884) exceeded its correlations with RTR (0.619) and SMU (0.769). These results validate the distinctiveness of each construct, ensuring minimal overlap within the model.

Table 1. Discriminant Validity Based on Fornell-Larcker Criterion

Fornell	CI	RTC	SMUE	SMUN	SMUI	MIN	RTR	RT	RTW	SMU	SMUS	RTU
CE	0.782											
RTC	0.797	0.859										
SMUE	0.822	0.731	0.794									
SMUN	0.648	0.586	0.679	0.824								
SMUI	0.777	0.68	0.8	0.673	0.75							
MIN	0.784	0.574	0.64	0.625	0.595	0.76						
RTR	0.764	0.6	0.69	0.535	0.651	0.646	0.85					
RT	0.882	0.874	0.801	0.686	0.764	0.714	0.835	0.719				
RTW	0.758	0.761	0.694	0.66	0.66	0.61	0.619	0.888	0.884			
SMU	0.842	0.739	0.889	0.873	0.911	0.688	0.683	0.835	0.769	0.715		
SMUS	0.781	0.652	0.719	0.784	0.824	0.643	0.578	0.743	0.739	0.924	0.816	
RTU	0.651	0.552	0.586	0.534	0.598	0.595	0.618	0.78	0.569	0.628	0.526	0.805

The findings support compelling validity, confirming that each construct represents a distinct dimension within the theoretical framework. This validation reinforces the accuracy of the measurement model, providing a solid foundation for further structural analysis and emphasizing the importance of distinguishing between constructs in the study.

4.3. Heterotrait-Monotrait Ratio (HTMT)

The HTMT values for most construct pairs remained under the recommended 0.90 threshold (Fornell & Larcker, 1981). Table 3 shows how the HTMT values in this study fall below the 0.90 threshold. Thus, the constructs demonstrate significant validity; where each construct reflects a unique aspect of MIN, SMU, RT, and CE in undergraduate students, without needless overlap.

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Table 2. HTMT ratios

Constructs	HTMT Ratios
CE	0.844
RTC	0.766
SMUE	0.792
SMUN	0.730
SMUI	0.839
MIN	0.684
RTR	0.729
RT	0.871
RTW	0.771
SMU	0.862
SMUS	0.798
RTU	0.696

The structural model (Fig. 1) was evaluated using Partial Least Squares Structural Equation Modeling (PLS-SEM) with Smart PLS 4.0. Following the confirmation of convergent validity in the measurement model, the analysis focused on assessing the model's predictive capacity and examining relationships among the research constructs. The evaluation adhered to established criteria to ensure a robust and reliable assessment.

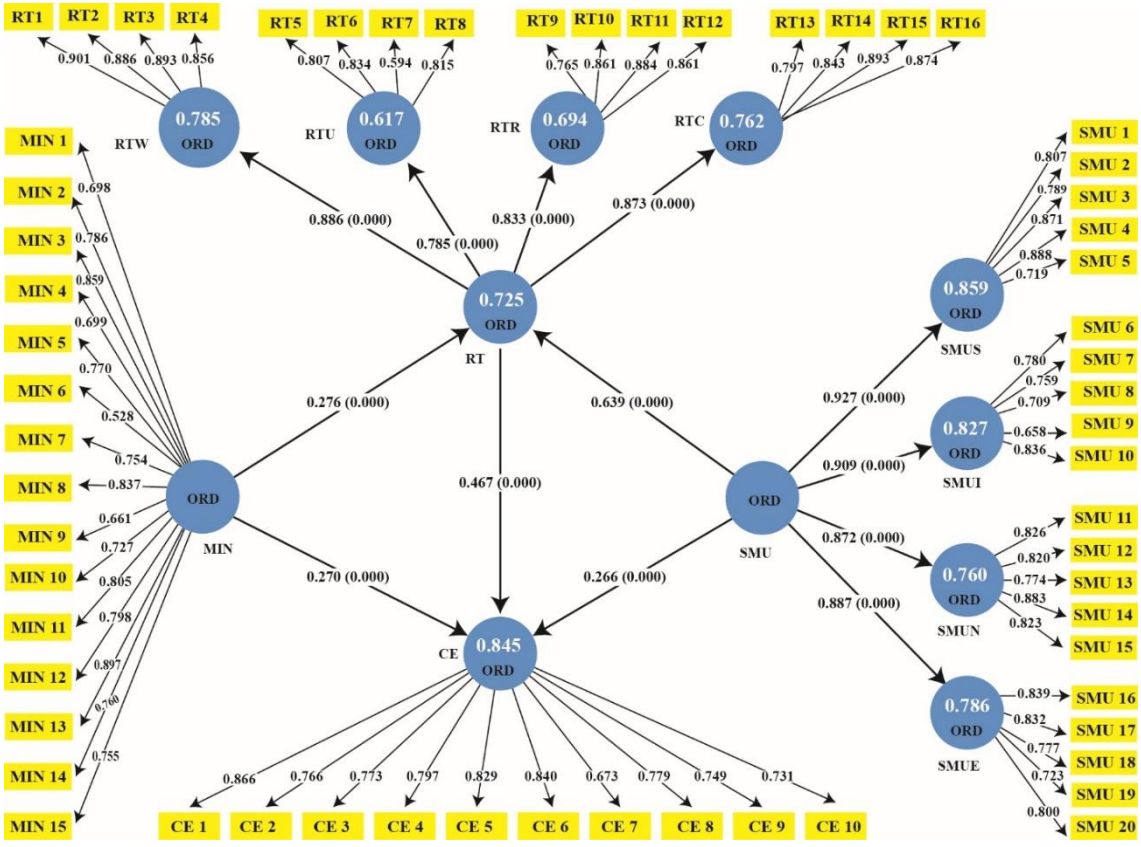

Figure 1. Path coefficients and (P-vale) in the structural model

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Table 4 presents the effect sizes of the study constructs, indicating a substantial impact across the model.

Table 4. Effect size f 2

Constructs	F^2
CE	0.219
RTC	0.148
SMUE	3.683
SMUN	3.161
SMUI	4.777
RTR	2.265
MIN	0.791
RTW	3.659
SMUS	6.071
RTU	1.609

Table 4 presents the effect scale of the study constructs, emphasizing their significant impacts. SMUS exhibited the largest effect size (f^2 = 6.071), followed by SMUI (f^2 = 4.777). These results highlight the crucial role of social media socialization and information in shaping RT and CE, reinforcing previous research on social media's influence on academic and emotional engagement (Muringani & Noll, 2021).

Likewise, SMU and RTW exhibited substantial effects, with f^2 values of 3.683 and 3.659, respectively, emphasizing the role of participatory education and routine work reflection in fostering deeper learning. This aligns with research highlighting reflective practices as a bridge between past experiences and new learning challenges (Chen, Hwang, & Chang, 2019). Furthermore, RT enhances MIN, resilience, and academic development, reinforcing its significance in promoting both psychological resilience and academic growth (Al-Rashidi & Aberash, 2024).

Medium effect sizes were found for MIN (f^2 = 0.791) and CE (f^2 = 0.219), reinforcing MIN's role in enhancing focus, emotional regulation, and reflective learning (Kabat-Zinn, 2001; Ghanizadeh & Ghonsooly, 2022). Research highlights MIN and RT as key contributors to cognitive development, as they both improve reading comprehension and reduce anxiety (Alsharhani, Ghonsooly, & Meidani, 2023). These findings are especially relevant in contemporary education, where SMU and CE are central to student engagement and development. Concurrently, RTU (f^2 = 1.609) and RTC (f^2 = 0.148) had smaller effect sizes, illustrating their less prominent yet important roles in the learning process.

The findings cohere with existing research emphasizing the roles of MIN, SMU, RT, and CE in modern education. Studies show that reflective practices enhance problem-solving, critical thinking, and knowledge organization (Kablan & Gunen, 2021). Likewise, MIN is proven to reduce cognitive distractions, improve focus, and promote academic success (Kabat-Zinn, 2001). The strong influence of social media constructs demands the integration of these tools in learning environments to maximize their benefits and minimize drawbacks (Throuvala et al., 2020). Further, MIN counteracts social media's negative effects by reducing overthinking and psychological distress while enhancing CE and mental well-being (Hong et al., 2021).

4.4. Predictive Relevance Q2

The Predictive Relevance (Q^2) value, also known as Stone-Geisser's Q^2, assesses the model's predictive relevance, while R^2 values indicate predictive accuracy (Hair et al., 2016). A Q^2 value above zero confirms the model's predictive relevance for a given reflective endogenous variable (Hair, Ringle, & Sarstedt, 2013). Table 5 shows how applying the blindfolding method with an omission

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distance (D) of 7 yielded Q^2 values greater than zero, confirming the strong predictive significance of our path model.

Table 3. Predictive relevance Q2 (construct cross validated redundancy) for key constructs

Constructs	RMSE	MAE	Q^2
CE	0.483	0.345	0.774
RTC	0.697	0.487	0.526
SMUE	0.475	0.328	0.782
SMUN	0.5	0.312	0.756
SMUI	0.425	0.276	0.824
RTR	0.728	0.553	0.488
MIN	0.539	0.421	0.716
RTW	0.651	0.504	0.584
SMUS	0.385	0.254	0.855
RTU	0.766	0.582	0.428

The Q^2 values confirm the strong predictive relevance of the path model for key constructs. SMUS recorded the highest Q^2 value (0.855), followed by SMUI (0.824) and SMUE (0.782). These results showcase the model's effectiveness in capturing social media's role in education, aligning with research concerning its impact on student engagement and cognitive outcomes (Muringani & Noll, 2021).

Further, CE (Q^2 = 0.774) and MIN (Q^2 = 0.716) demonstrated strong predictive relevance, reinforcing their roles in enhancing focus, emotional regulation, and reflective learning (Kabat-Zinn, 2001). RTW (Q^2 = 0.584) and RTC (Q^2 = 0.526) also show substantial predictive relevance, aligning with research emphasizing the impact of reflective practices on critical thinking and problem-solving (Chen, Hwang, & Chang, 2019). These findings confirm the model's strong predictive capability in capturing the relationships between MIN, SMU, RT, and CE. Effectively integrating these constructs provides valuable insight into how modern educational practices can utilize them to enhance deeper learning and improve student outcomes.

4.5. Findings for the Research Question

This study poses the question: "What are the interactions and impacts of MIN, SMU, RT, and CE among undergraduate students?" This question is explored through the seven hypotheses (H1–H7), each examining the relationships between these constructs.

Table 5. Hypotheses Testing

Hypothesis	Direction	β coefficient	Std.	t Value	p Value	Result
H1	MIN → RT	0.276	0.059	4.688	0.00	Supported
H2	MIN → CE	0.399	0.065	6.099	0.00	Supported
H3	SMU → RT	0.639	0.054	11.807	0.00	Supported
H4	SMU → CE	0.565	0.059	9.609	0.00	Supported

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H5	RT → CE	0.467	0.054	8.673	0.00	Supported
H6	MIN → RT → CE	0.129	0.03	4.284	0.00	Supported
H7	SMU → RT → CE	0.298	0.045	6.701	0.00	Supported

The table demonstrates the structural relationships among MIN, SMU, RT, and CE, showcasing their direct and indirect effects. It highlights MIN and SMU as strong predictors of RT and CE.

MIN and SMU played a crucial role in strengthening RT and CE. Research indicates that MIN reduces cognitive distractions, enhances awareness, and supports emotional regulation; all of which are key factors for deep learning and reflection. Likewise, strategic SMU fosters participatory learning and collaboration, promoting RT and deeper involvement (David & Sheth, 2009; Muringani & Noll, 2021).

The hypothesis testing results strongly supported the proposed relationships (see Table 5). Path coefficients indicated significant positive impacts of MIN on both RT ($\beta = 0.276$, $t = 4.688$, $p < 0.001$) (H1) and CE ($\beta = 0.399$, $t = 6.099$, $p < 0.001$) (H2). Likewise, SMU positively influenced RT ($\beta = 0.639$, $t = 11.807$, $p < 0.001$) (H3) and CE ($\beta = 0.565$, $t = 9.609$, $p < 0.001$) (H4). Additionally, RT significantly impacted CE ($\beta = 0.467$, $t = 8.673$, $p < 0.001$) (H5), reinforcing its role as a vital driver of cognitive processes.

Mediation analysis underscored RT's vital role in enhancing CE. RT fosters deeper learning by enabling students to critically assess and refine their learning and problem-solving strategies. Mindfulness-based interventions further support this process by reducing overthinking and improving emotional regulation, directly benefiting RT and CE. Mao et al. (2023) highlighted RT's contribution to self-regulated learning and emotional awareness with high-achieving students. Notably, RT partially mediated the relationship between MIN and CE ($\beta = 0.129$, $t = 4.284$, $p < 0.001$) (H6) and between SMU and CE ($\beta = 0.298$, $t = 6.701$, $p < 0.001$) (H7), reinforcing its role in amplifying the positive effects of MIN and SMU on CE.

MIN explained nearly 50% of the variance in RT abilities, highlighting its transformative impact on academic growth. Likewise, when used mindfully, social media enhanced RT and CE by facilitating knowledge-sharing and collaboration. However, its strategic integration is essential to minimize potential drawbacks. A 2024 study affirmed that MIN and SMU significantly shaped reflective and cognitive abilities in university students, reinforcing the importance of aligning their use with educational goals (Ghanizadeh & Ghonsooly, 2022; Muringani & Noll, 2021).

Overall, the results supported the validity of the structural model and highlight the dynamic interplay among MIN, SMU, RT, and CE in shaping educational outcomes. While the findings greatly aligned with previous literature, subtle variations, such as the minor effect of RTC and a few lower item loadings, highlight the complexity of educational processes. These nuances suggest the need for future research to explore additional mediating variables and employ longitudinal designs to better capture causal relationships.

4.6. Practical Implications of the Research Findings

This study provides valuable insights into the interactions between MIN, SMU, RT, and CE in enhancing undergraduate education. These findings offer actionable recommendations for educators, policymakers, and institutions aiming to harness these constructs for improved academic performance.

Promoting Mindfulness Practices

The strong effects of MIN on RT ($\beta = 0.276$) and CE ($\beta = 0.399$) underscore its vital role in enhancing awareness, emotional regulation, and resilience. Integrating MIN programs, such as

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guided meditations, workshops, and reflective exercises, into educational frameworks can equip students with essential cognitive and reflective skills for academic success.

Integrating RT Strategies

RT plays a crucial mediating role between MIN, SMU, and CE, with a significant impact on CE (β = 0.467). Professional development programs should encourage reflective practices like journaling, group discussions, and peer mentoring, to help students bridge prior knowledge with new challenges and strengthen their critical thinking skills.

Strategic Use of Social Media in Education

SMU has strong direct effects on RT (β = 0.639) and CE (β = 0.565), highlighting its value in collaborative learning and engagement. Institutions should develop interactive social media activities that enhance learning while minimizing distractions and overuse. Mindfulness-based approaches can further support purposeful social media use.

Curriculum Development and Support

Curriculum designers should embed MIN, SMU, and RT into learning objectives through technology-driven projects, collaborative tasks, and reflective assignments. The strong effect sizes of SMUS (f^2 = 6.071) and SMUI (f^2 = 4.777) highlight the importance of socialization and information-sharing for enhancing RT and CE.

Fostering a Culture of Enjoyment and Engagement

The positive correlation between enjoyment and CE creates the need for a supportively engaging learning environment. Institutions should promote innovative tools and methods, building a culture of continuous learning which empowers students and educators to explore new technologies and approaches.

These findings accentuate the interconnected roles of MIN, SMU, RT, and CE in academic success. Integrating MIN, encouraging RT, and strategically utilizing social media can create enriched learning environments that equip students for modern educational demands. Such recommendations offer a framework for improving both academic performance and personal growth in undergraduate students.

5. Conclusion

This study examines the complex relationships among MIN, SMU, RT, and CE in undergraduate students. The findings confirm the strong positive effects of MIN and SMU on RT and CE, with RT serving as a key mediator. These results align with and expand upon prior research, highlighting the transformative role of MIN and SMU in improving academic outcomes.

The results validate all seven hypotheses, confirming the interconnectedness of MIN, SMU, RT, and CE. MIN enhances RT and CE by fostering awareness, emotional regulation, and resilience. Meanwhile, SMU strengthens these constructs through collaboration, knowledge-sharing, and participatory learning. Further, RT plays a mediating role, enhancing the positive effects of MIN and SMU on CE. These results grant a comprehensive understanding of the intricate dynamics between MIN, SMU, RT, and CE and their interplay in educational settings.

This study provides valuable insights for educators and policy makers. It reveals the benefits of integrating MIN practices and structured social media activities in education to enhance learning experiences. It also highlights RT's potential in improving CE and academic outcomes.

Further research is advised for the long-term effects of these constructs on academic achievement and personal growth across various educational contexts. Additionally, exploring their

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impact within specific disciplines or educational levels may provide further insight into their applications.

In conclusion, MIN, SMU, RT, and CE are interconnected constructs that collectively enrich the learning experience. This study highlights their dynamic interplay, offering a strong foundation for enhancing educational practices and promoting student success.

Declarations

Author Contributions. The author solely conceptualized the study, designed the methodology, collected and analyzed the data, and wrote the manuscript. The author reviewed and approved the final version of the manuscript.

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Ethical Approval. This study was conducted in accordance with ethical guidelines, and ethical approval was obtained from the Institutional Review Board in Ramallah (Approval No: R-2025/A/9/N). Informed consent was obtained from all participants before their participation in the study.

Data Availability Statement. The data supporting this study is available upon request from the author

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