

DIFFERENCES IN BIOLOGY STUDENTS' SELF-REGULATION DURING ONLINE AND OFFLINE LEARNING AND ITS RELATIONSHIP TO LEARNING OUTCOMES

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ARTICLE INFO	ABSTRACT
<p>Article History: Received 19/12/2023 Revised 19/01/2024 Approved 13/02/2024 Published 01/03/2024</p> <hr/> <p>Keywords: Self-regulation Online learning Offline learning Learning outcomes</p>	<p>The cultivation of self-regulatory skills holds paramount importance for individuals' future success, particularly in the context of evolving educational modalities prompted by the Covid-19 pandemic. As learning transitions between online during the pandemic and offline post-pandemic, understanding the nuances of self-regulation becomes imperative. Thus, this study sought to achieve three objectives: (1) analyzing disparities in student self-regulation between online and offline settings, (2) examining the interplay between online and offline self-regulation, and (3) scrutinizing the relationship between self-regulation and learning outcomes. Employing a methodological approach involving questionnaire administration, interviews, and collecting academic scores data, data analysis was conducted utilizing the Wilcoxon Signed Ranks test and Spearman's rho test. The findings reveal that offline self-regulation markedly surpasses its online counterpart, indicating a significant discrepancy. Furthermore, a robust correlation is observed between students' self-regulation during online learning and the subsequent development of offline self-regulation. Additionally, while the correlation between self-regulation and learning outcomes is characterized as weak, it underscores the tangible influence of self-regulation on enhancing academic achievements. These findings underscore the critical role of self-regulation in navigating diverse learning environments and underscore the need for targeted interventions to bolster students' self-regulatory competencies.</p>
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INTRODUCTION

Self-regulation stands out as a pivotal skill set poised to shape the landscape of future human endeavors. As projected by the Organization for Economic Cooperation and Development (OECD), self-regulation emerges as a cornerstone competency requisite for the workforce of 2030 (OECD, 2019), fostering traits of autonomy and accountability (Mejeh & Held, 2022). Crucially, within educational contexts, mastery of these skills becomes imperative for attaining academic excellence. Nevertheless, prevailing data indicate a concerning deficit in self-regulatory capacities among students. Lin et al. (2021) reveal that a substantial 31.7% of a cohort comprising 378 Chinese students exhibit inadequate self-regulation, marked by diminished motivation and ineffective learning strategies. Similarly, Broadbent and Fuller-Tyszkiewicz (2018) underscore this issue, reporting that 33.2% of 606 students manifest deficiencies in managing their learning methodologies. Moreover, Schwam et al. (2021) find that a significant 40.5% out of 477 students exhibit self-regulation scores below the established norm across all assessed parameters.

Individual differences in self-regulation skills are well-documented (Nakata, 2020), highlighting the necessity for students to adapt their organizational approaches to varying learning environments. Amidst the global pandemic, the Indonesian government enforced online learning mandates from early 2020 to 2022. Despite efforts to mitigate obstacles, such as learning loss, pervasive challenges persist (Solihat et al., 2022). The inherent limitations of online modalities, including the inability to grasp complex concepts fully, exacerbate the educational landscape (Mishra et al., 2020). Moreover, the prolonged duration of online learning engenders fatigue



among students (Bonk, 2020), which, if left unaddressed, compromises their cognitive faculties and detrimentally impacts academic performance (Engzell et al., 2021).

Under the constraints of these circumstances, students are compelled to adapt adeptly, particularly in the domains of time management and task completion, to optimize outcomes (Tabuenca et al., 2022). Effective time management emerges as a cornerstone for attaining educational objectives amidst such exigencies (Wolters & Brady, 2021). The exigencies of the pandemic precipitate a heightened emphasis on self-regulation, propelling students towards cultivating autonomy in delineating learning objectives, orchestrating study regimens, and achieving educational milestones (Pelikan et al., 2021). Moreover, students bear the onus of executing a myriad of tasks, including crafting papers and presentations, undertaking practical exercises and projects autonomously, scrutinizing scholarly literature, and advancing their theses.

While online learning offers students the flexibility to hone their self-regulation skills, this very flexibility can yield adverse effects on the learning process. The abundance of flexibility may inadvertently breed complacency among students, leading to procrastination in task completion due to a perceived surplus of time, consequently yielding suboptimal outcomes (Artino Jr & Stephens, 2009). Moreover, the erosion of lecturer oversight inherent in online platforms can contribute to a decline in students' sense of accountability (Alzahrani, 2022). This erosion is evident in scenarios where students engage in multitasking during online discussions, diverting attention away from academic endeavors. Furthermore, the dearth of peer interaction fosters a self-centered and individualistic disposition (Lin & Dai, 2022), potentially hindering collaborative learning experiences essential for holistic academic development.

Post-pandemic, a transition towards offline learning in universities becomes imperative. The dynamic of student organization differs significantly between online and offline modalities, particularly in the realm of time management. Offline learning necessitates meticulous time allocation, considering the additional time required for commuting to campus and managing various academic tasks amidst other responsibilities (Lin & Dai, 2022). Conversely, offline environments engender heightened motivation among students, stemming from direct interactions with lecturers and peers—a stimulus often lacking in online settings (Adarkwah, 2021; Barak et al., 2016). In the classroom, lecturers wield greater influence, fostering active student participation and ensuring accountability for assignments, a dynamic less feasible in online learning contexts.

The intricacies of student challenges encountered in both online and offline learning environments significantly influence their organizational strategies in navigating the educational journey. Students adept at cultivating self-regulation skills amidst online learning environments typically transition more smoothly to offline learning paradigms, as they have honed discipline and exhibit reduced tendencies towards procrastination in completing assignments independently (Barak et al., 2016; Pelikan et al., 2021). Moreover, the inherently high levels of intrinsic motivation observed among students engaged in online learning translate into heightened enthusiasm towards classroom participation in offline settings (Quesada-Pallarès et al., 2019). Furthermore, having developed a capacity for sustained focus and enthusiasm for tackling intricate tasks during online learning, students are better equipped to tackle complex assignments in offline learning scenarios, benefitting from the training received in virtual environments (Turan et al., 2022).

Conversely, students who struggle to cultivate self-regulation skills during online learning may encounter challenges when transitioning to offline learning environments. Inadequate time management practices in online learning contexts can exacerbate difficulties in offline learning, where time demands are typically greater. Furthermore, a lack of discipline observed during online learning often translates into diminished responsibility levels in offline settings. Suboptimal management of learning strategies not only impairs academic efficacy (Wang & Kao, 2022) but also heightens anxiety and stress levels, detrimentally impacting student performance (Broadbent & Fuller-Tyszkiewicz, 2018). Consequently, proficient self-regulation among students yields positive learning outcomes (Wang et al., 2022a), whereas deficiencies in self-regulation exert a negative influence (Park et al., 2019).

In evaluating student learning outcomes, the Achievement Index serves as a common metric, although it fails to comprehensively capture the intricacies of self-regulation abilities. This limitation stems from the fact that traditional assessments often lack specificity in evaluating self-regulatory skills (Zhang & Li, 2019). While e-portfolios and learning journals offer alternative means to gauge these abilities, they too possess inherent limitations in effectively documenting the progression of self-regulation processes (van der Gulden et al., 2020). Despite these challenges, the predominant determinants of student academic scores continue to be the Midterm Exam and Final Semester Examination. Nevertheless, the AI value persists as a prominent reference point for assessing student learning achievements, albeit with acknowledgment of its limitations.

In today's professional landscape, emphasis has shifted from mere values to an individual's capacity for self-regulation, which significantly impacts productivity and goal attainment within companies. Companies prioritize candidates who demonstrate the ability to set and regulate their own goals effectively, as aligning personal interests and skills with job responsibilities increases the likelihood of success while reducing the risk of frustration and unproductive outcomes (Iliescu et al., 2015). Proficiency in self-organization equips individuals with the resilience to navigate diverse challenges encountered in the workplace (Firoozabadi et al., 2018). Moreover, strong self-motivation positively influences engagement and performance in professional roles (Turner et al., 2022). Additionally, companies consider an individual's emotional regulation abilities crucial in managing adverse situations involving inter-organizational conflicts or disputes (de Clercq et al., 2020).

Moreover, the significance of self-regulation extends to students pursuing higher education. Universities prioritize this attribute in the admission process, evident in recommendation letters scrutinizing various facets of students' capabilities, including time management, self-motivation, academic interests, attitudes, integrity, responsibility, independence, and adaptability. This emphasis is grounded in the recognition that self-regulation facilitates effective strategizing and behavior management, enabling timely completion of academic endeavors (Zhu et al., 2020). Furthermore, students who develop these skills demonstrate an enhanced capacity to excel academically (Korostyshevskiy, 2021).

Based on the foregoing, this study aims to achieve three primary objectives. Firstly, it seeks to analyze the divergence in self-regulation among biology students in both online and offline learning environments. Secondly, it aims to examine the relationship between the self-regulation levels of biology students during online learning sessions and those in offline learning settings. Lastly, the study endeavors to explore the correlation between the self-regulation competencies of biology students and their academic learning outcomes. By delving into these objectives, the research aims to provide insights into the dynamics of self-regulation in biology education across different learning modalities and its implications for student performance.

METHOD

This study adopts an ex post facto research design, conducted between June and September 2023 at the Department of Biology, Faculty of Mathematics and Natural Sciences, State University of Malang. The study population comprises all undergraduate students enrolled in the biology and biology education programs at the aforementioned institution in 2021, who underwent a combination of online and offline learning modalities. Employing a total sampling technique, the initial population comprised 216 students. Following rigorous data verification procedures, a final sample of 195 students, comprising 107 Biology Education students and 88 Biology students, was deemed eligible for inclusion in the study based on predetermined criteria.

The research employs a self-regulation questionnaire derived from [Barnard et al. \(2009\)](#), adapted to suit the context of this study. This questionnaire encompasses two distinct versions tailored for online and offline learning environments, comprising 37 statement items each. Seven key indicators, namely goal setting, environmental structuring, task strategy, time management, persistence, help-seeking, and self-evaluation, are assessed within these questionnaires. Responses are recorded on a Likert scale ranging from 1 to 4. Prior to implementation, the questionnaire underwent rigorous validation procedures, including logical and empirical validity tests, alongside reliability assessments. The second research instrument comprises an interview sheet comprising 29 questions. Finally, academic scores of biology students from the 2021 cohort serve as the third research instrument.

Data collection involved distributing questionnaires to students, allowing them one week to complete them. Subsequently, interviews were conducted with students to gather additional insights. The third dataset comprised semester-wise achievement index scores from the academic records. Statistical analyses were tailored to the nature of the data. Specifically, the Wilcoxon Signed Ranks Test was employed for comparing pre- and post-test scores, given the non-normal distribution of the questionnaire responses. For the interviews and academic scores, the Spearman rho test was utilized due to similar non-normal distribution characteristics. Furthermore, the interview outcomes served to validate and provide detailed explanations of observed phenomena.

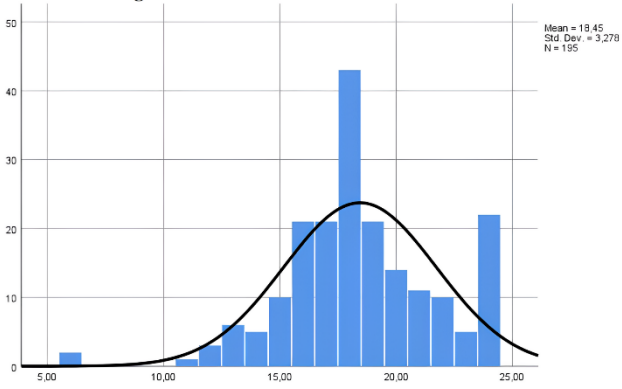
RESULTS

Data pertaining to students' self-regulation proficiency during online learning sessions was acquired subsequent to the distribution and completion of questionnaires. Notably, the analysis reveals specific indicators of self-regulation performance. The goal-setting indicator exhibited an average score of 18.45, accompanied by a standard deviation of 3.278. Similarly, the environmental arrangement indicator yielded an average score of 16.56, with a standard deviation of 2.37. Furthermore, the task strategy indicator garnered an average score of 18.45, demonstrating a standard deviation of 2.894. Additionally, the time management indicator recorded an average score of 15.18, with a standard deviation of 2.718, while the persistence indicator exhibited an average score of 15.60, with a standard deviation of 2.579. Moreover, the help-seeking indicator displayed an average score of 14.37, possessing a standard deviation of 2.649, while the self-evaluation indicator registered an average score of 14.63, alongside a standard deviation of 2.592. Collating these results, the cumulative self-regulation ability during online learning sessions among students amounted to an average score of 112.64, with a standard deviation of 15.007. Notably, the standard deviation across all indicators was lower than the respective average scores, indicating the absence of extreme data points ([Figure 1](#)).

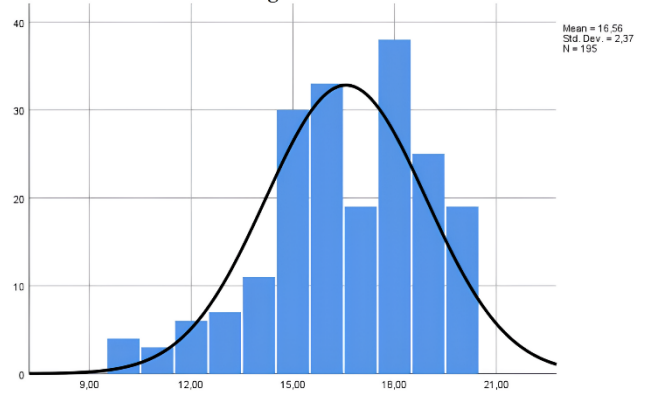
Furthermore, data pertaining to students' self-regulation proficiency during offline learning sessions was also collected and analyzed. The goal-setting indicator exhibited an average score of 19.28, accompanied by a standard deviation of 3.379, whereas the environmental arrangement indicator yielded an average score of 16.14, with a standard deviation of 2.707. Similarly, the task strategy indicator garnered an average score of 18.50, demonstrating a standard deviation of 2.908. Additionally, the time management indicator recorded an average score of 15.89, with a standard deviation of 2.586, while the persistence indicator exhibited an average score of 16.56, with a standard deviation of 2.536. Moreover, the help-seeking indicator displayed an average score of 15.84, possessing a standard deviation of 2.549, while the self-evaluation indicator registered an average score of 15.39, alongside a standard deviation of 2.512. Aggregating these findings, the overall self-regulation ability during offline learning among students amounted to an average score of 117.60, with a standard deviation of 16.35. Remarkably, the standard deviation across all indicators was lower than the respective average scores, signifying the absence of outlier data points ([Figure 2](#)).

The data analysis revealed discernible disparities in students' self-regulation abilities between online and offline learning contexts. Specifically, during online learning sessions, 49.23% of students demonstrated a high level of self-regulation, whereas in offline learning environments, this proportion increased to 60%, indicating a greater prevalence of high self-regulation among students during offline learning. Conversely, in the realm of online learning, 50.26% of students exhibited a moderate level of self-regulation, whereas during offline learning, this percentage decreased to 38.97%, suggesting a higher prevalence of moderate self-regulation during online learning. Notably, the variance in the low self-regulation category was relatively minor, with a marginal difference of 0.51% observed in online learning and 1.02% in offline learning ([Figure 3](#)).

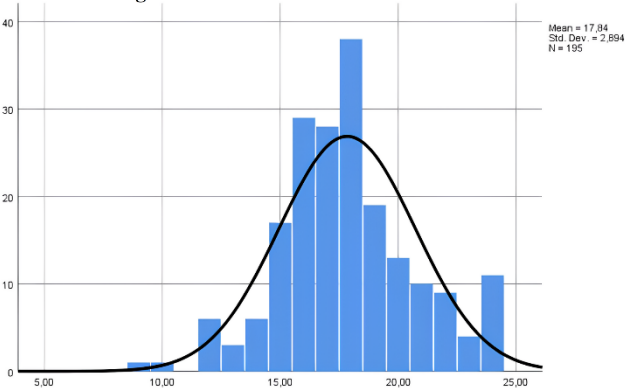
A. Goal Setting



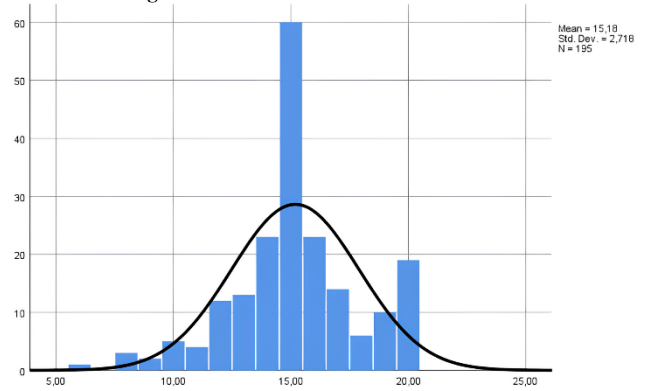
B. Environment Structuring



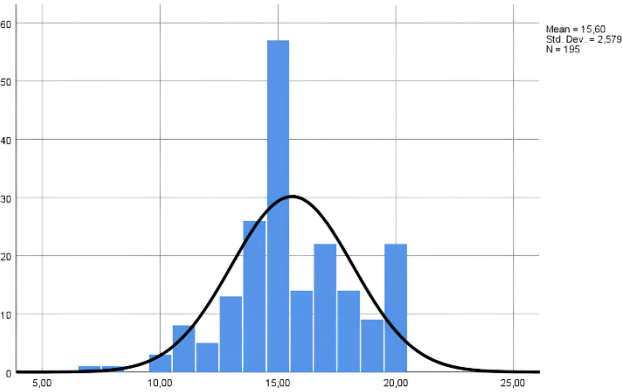
C. Task Strategies



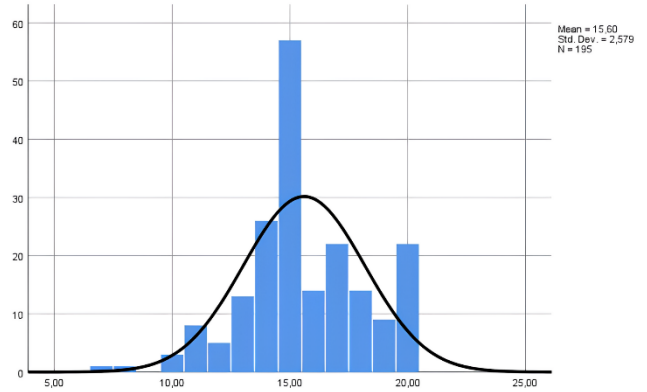
D. Time Management



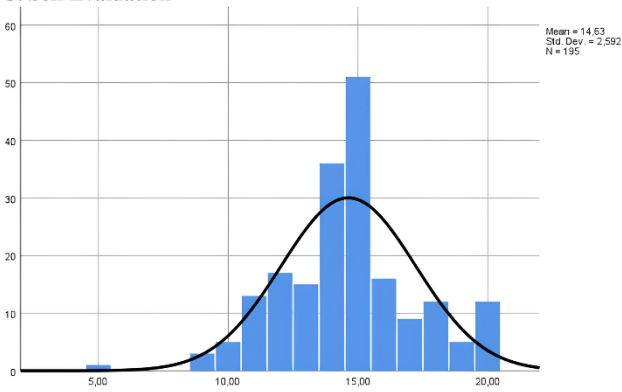
E. Persistence



E. Persistence



G. Self Evaluation



H. Self Regulation Total

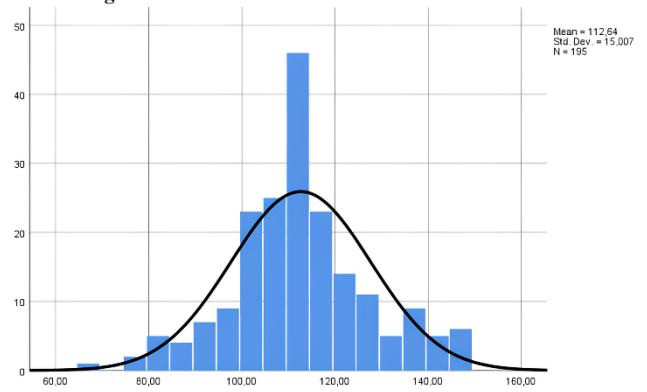
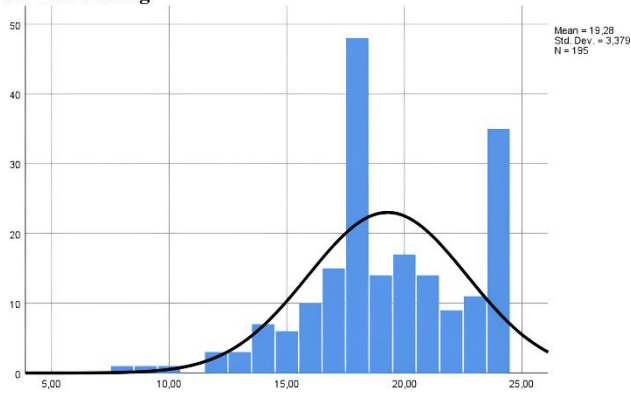
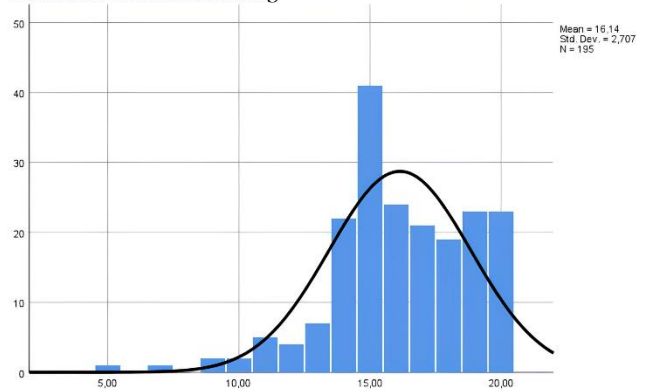


Figure 1. Distribution of students' self-regulation skills during online learning.

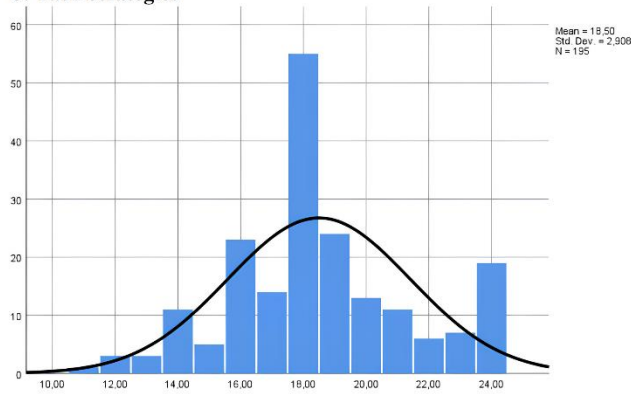
A. Goal Setting



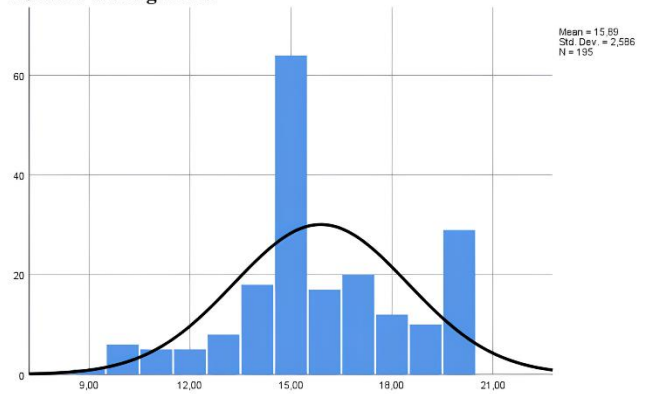
B. Environment Structuring



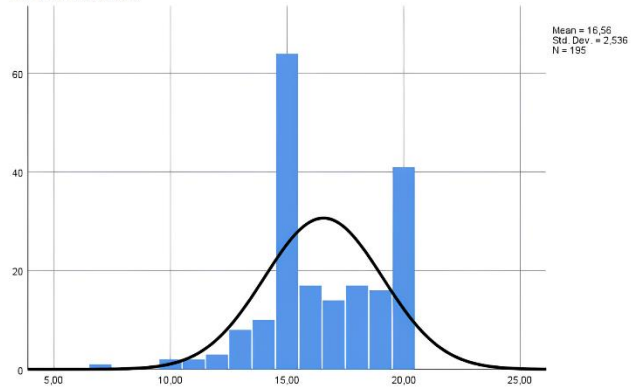
C. Task Strategies



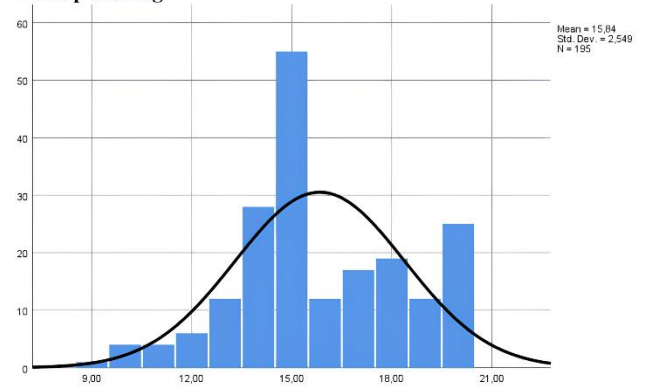
D. Time Management



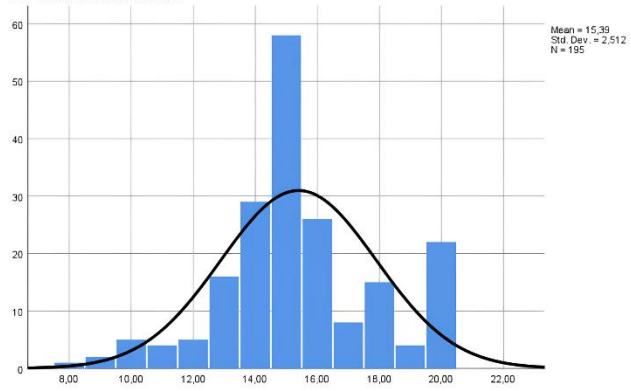
E. Persistence



F. Help Seeking



G. Self Evaluation



H. Self Regulation Total

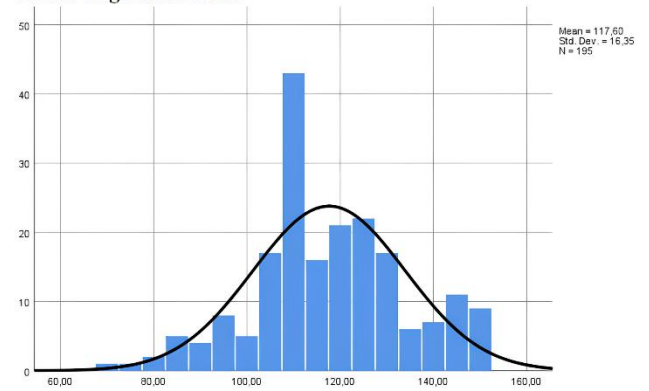


Figure 2. Distribution of students' self-regulation skills during offline learning.

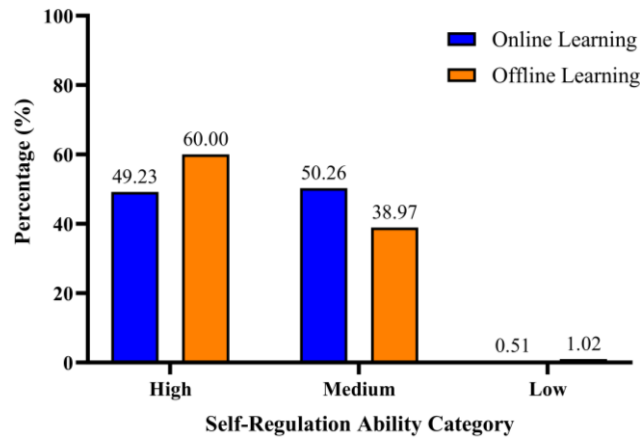


Figure 3. Students' self-regulation ability category

The comparison between online and offline learning contexts highlights notable differences in students' self-regulation across various indicators (Figure 4a). In online learning, the average score for goal-setting stands at 18.45, whereas in offline learning, it rises to 19.28, indicating a more adept ability among students to establish goals during offline learning. Conversely, regarding the structuring of the learning environment, online learning yields an average score of 16.56, slightly surpassing the score of 16.14 observed in offline learning, suggesting a marginally better ability to manage learning environment conditions during online sessions. Similarly, in terms of task strategy, online learning garners an average score of 18.45, compared to 18.50 in offline learning, implying a slightly superior utilization of assignment strategies during offline learning. Regarding time management, online learning reflects an average score of 15.18, whereas offline learning demonstrates an average score of 15.89, suggesting a more effective time management skill set among students during offline learning sessions.

Furthermore, regarding persistence, online learning records an average score of 15.60, whereas offline learning displays a higher average score of 16.56, indicating greater persistence levels among students in offline learning settings. Similarly, the help-seeking indicator in online learning records an average score of 14.37, compared to 15.84 in offline learning, implying a more adept ability to seek assistance during offline learning sessions. Moreover, the self-evaluation indicator in online learning reflects an average score of 14.63, slightly below the score of 15.39 observed in offline learning, suggesting a comparatively better self-evaluation proficiency among students during offline learning.

Overall, the cumulative self-regulation ability during online learning manifests an average score of 112.64, whereas offline learning exhibits a higher average score of 117.60, underscoring students' superior self-regulation skills in offline learning contexts (Figure 4b). Additionally, student learning outcomes during online learning have an AI value of 3.60 with a standard deviation of 0.178, while in offline learning, the average student has an AI value of 3.63 with a standard deviation of 0.164. This indicates that students achieve better learning outcomes when engaged in offline learning (Figure 5).

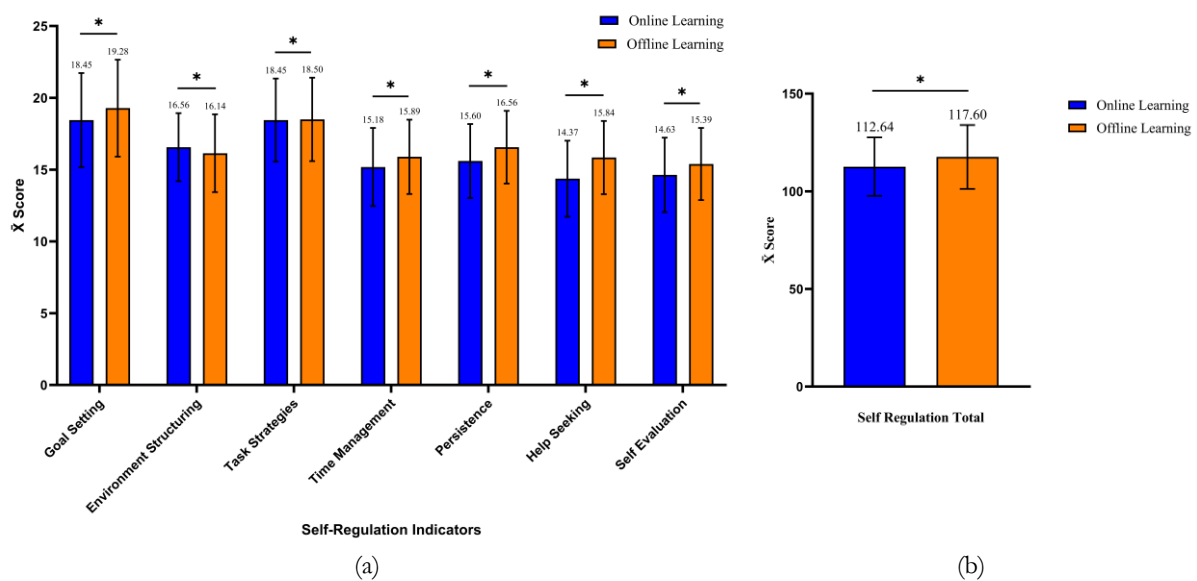


Figure 4. Differences of students' self-regulation ability in (a) each indicator, (b) total.

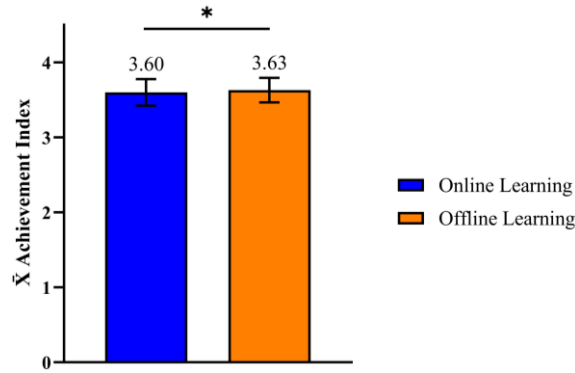


Figure 5. Students' learning outcomes.

The Wilcoxon Signed Ranks Test was utilized to assess the variance in students' self-regulation ability between online and offline learning contexts, examining all indicators of self-regulation proficiency. Results from this test reveal that all indicators exhibit a significance value of <0.05. Consequently, hypothesis 1 is affirmed, indicating discernible disparities in self-regulation ability during online and offline learning sessions (Table 1).

Furthermore, the Spearman rho correlation test was employed to explore the association between students' self-regulation ability in online and offline learning environments. The analysis yielded a significance value of <0.05, thereby validating hypothesis 2. This indicates a positive relationship between students' self-regulation abilities during online and offline learning, with a coefficient value of 0.752 (Table 2). Notably, the coefficient value denotes a robust correlation between these variables (Figure 6).

Table 1. The results of the test are different in students' self-regulation ability.

Indicators	Significance Value	5% rate	Information
Goal setting	0.00	0.05	Significantly different
Environment structuring	0.03	0.05	Significantly different
Task strategies	0.00	0.05	Significantly different
Time management	0.00	0.05	Significantly different
Persistence	0.00	0.05	Significantly different
Help-seeking	0.00	0.05	Significantly different
Self evaluation	0.00	0.05	Significantly different
Self-regulation total	0.00	0.05	Significantly different

Table 2. The results of the correlation test between the ability of online self-regulation and offline self-regulation.

Correlation	Significance Value	Coefficient Value	5% Rate	Information
Online self-regulation – Offline self-regulation	0.000	0.752	0.05	Strong correlation

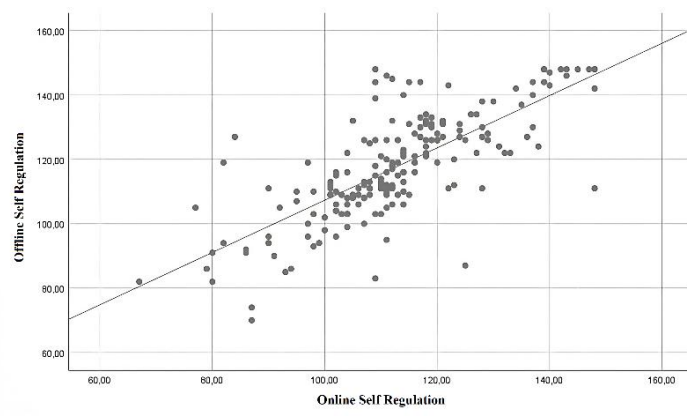
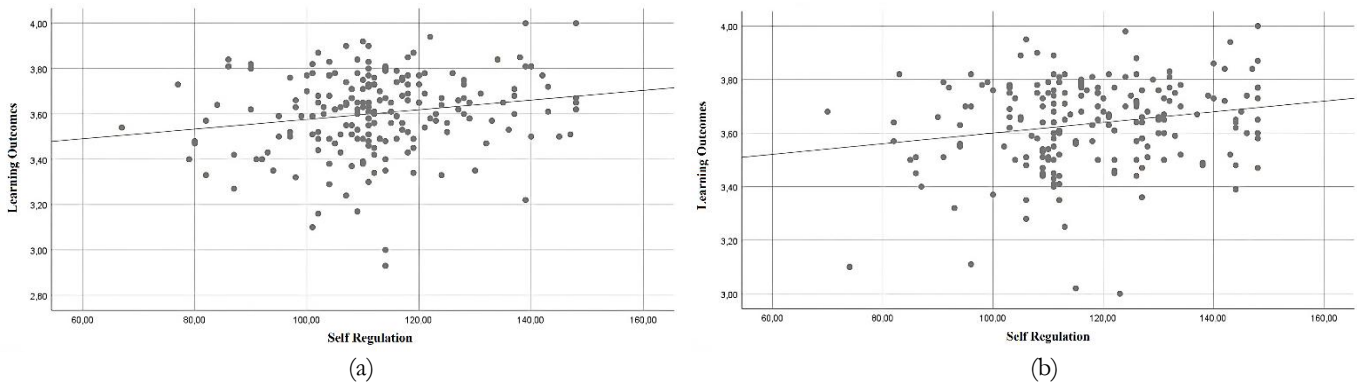


Figure 6. Correlation of online with offline self-regulation.

Table 3. The results of the correlation test between self-regulation ability and learning outcomes.

Correlation	Significance Value	Coefficient Value	5% Rate	Information
Online self regulation - Online learning outcomes	0.016	0.172	0.05	Very weak correlation
Offline self regulation - Offline learning outcomes	0.035	0.151	0.05	Very weak correlation

**Figure 7.** The correlation between (a) online self-regulation and online learning outcomes, (b) offline self-regulation and offline learning outcomes.

The Spearman rho correlation test is also used to determine the relationship between students' self-regulation ability and learning outcomes. The results of the correlation test showed a significance value of <0.05 , so hypothesis 3 was accepted, which means that there is a positive relationship between self-regulation ability and student learning outcomes with correlation coefficient values of 0.172 (online) and 0.151 (offline) (Table 3). The value of such coefficients shows a very weak correlation (Figure 7).

DISCUSSION

The findings of this investigation elucidate the disparity in self-regulatory aptitude between offline and online learning modalities, as illustrated in Figure 4b. Offline learning environments afford students a greater capacity for self-adaptation and regulation compared to their online counterparts. This is attributable to the enhanced ability of students to strategize, implement, and assess their learning processes within the offline context. Conversely, the challenges encountered in fostering self-regulation during online learning persist for many students. This may be attributed to their nascent status within the educational milieu, thereby lacking the requisite time for acclimatization to the collegiate learning paradigm. Notably, tertiary education imposes heightened demands for autonomous learning vis-à-vis secondary education (Krasilnikov & Smirnova, 2017). Additionally, students confront heightened academic rigors (Krasilnikov & Smirnova, 2017; Kreniske, 2017). Further delineation of the contrasting facets of self-regulation in online versus offline learning is expounded upon through a granular analysis of individual indicators below.

In the context of goal-setting, the findings of this investigation underscore a pronounced disparity in students' efficacy in setting objectives between offline and online learning environments, as depicted in Figure 4a and Table 1. Notably, students demonstrate a superior ability to establish clear and coherent learning goals in offline settings compared to online platforms. This discrepancy is attributed to the inherent advantages of offline learning, wherein students more readily engage in deliberate goal-setting practices. Offline learning environments afford students the opportunity to discern their learning objectives with greater clarity and frequency. Research suggests that students who possess a clear understanding of their learning objectives are more inclined to articulate specific goals conducive to academic success (Beckman et al., 2021). Effective learning objectives embody the SMART criteria, delineating goals that are specific, measurable, achievable, relevant, and time-bound (Dotson, 2016). Conversely, the virtual nature of online learning may engender a perception among students that participation in lectures suffices as the primary learning activity, thereby mitigating the inclination to establish specific goals. The deficiency or absence of clearly defined goals among online learners may stem from a lack of comprehensive understanding regarding their learning objectives (McCardle et al., 2017). It is imperative to note that clear goal-setting plays a pivotal role in cultivating and sustaining self-regulatory behaviors, including planning, monitoring, and reflective practices (Wäschle et al., 2014).

In offline learning contexts, a notable proportion of students exhibit proficiency in integrating technology purposefully into their goal-setting endeavors, whereas in online learning environments, certain students demonstrate a less judicious utilization of technological resources. This is evidenced by instances where online learners prioritize documenting their learning activities over actively engaging with lecture content. Such indiscriminate use of technology can significantly undermine students' ability to effectively establish and pursue their learning objectives (Durak & Uslu, 2023). Consequently, cultivating students' awareness regarding the critical role of goal-setting becomes imperative in fostering robust self-regulatory skills (Handoko et al., 2019). Furthermore, the involvement

of academic advisors is indispensable in overseeing and guiding students' goal-setting endeavors (Bowman et al., 2020), thereby reinforcing the importance of collaborative efforts in promoting students' academic success and self-regulatory competencies.

In the realm of environmental arrangement, this study reveals a notable discrepancy wherein students exhibit a heightened capacity to manage their learning environment more effectively during online learning as opposed to offline learning, as depicted in Figure 4a and Table 1. This phenomenon is attributable to the flexibility afforded to students in configuring their learning spaces to optimize comfort and efficiency in online settings. Research underscores the pivotal role of a conducive learning environment in facilitating the learning process (Hapsari & Fatmasari, 2022; Wolters, 2003). Common disruptions encountered in traditional offline settings, such as overcrowding and noise, often impede the learning experience. Conversely, online learners have the autonomy to circumvent such disruptions by selecting quiet and efficient study spaces. In contrast, in offline learning environments, students may acquiesce to crowded conditions as the norm, thereby exerting less effort towards creating an optimal learning atmosphere. Such overcrowded conditions invariably impede learning efficiency (Yang et al., 2023). Mitigating social distractions, such as requesting peers to maintain silence, is imperative for curating an ideal learning environment (Wolters, 2003). Furthermore, students can enlist the support of instructors to cultivate and sustain a conducive classroom ambiance (Salarvand et al., 2023), underscoring the collaborative effort necessary to optimize learning environments and enhance educational outcomes.

Disruptions in technology usage also pose challenges in the learning process. During instances of internet disruptions in online learning settings, students typically demonstrate a proactive approach in seeking solutions to ensure smooth internet connectivity. Conversely, in offline learning scenarios, some students exhibit a lack of initiative in addressing technological disruptions. These students may fail to take proactive measures such as changing classrooms or relocating to areas with better technological support. However, proficient utilization of available digital tools can significantly enhance students' self-regulation skills and subsequently improve academic achievement (Sutarni et al., 2021). Consequently, the ability to adapt to the learning environment emerges as a crucial factor, with greater adaptability observed among students in online learning contexts. Adaptability in learning environments correlates positively with enhanced engagement and motivation (Bannert et al., 2015). Moreover, students who effectively curate their learning environments demonstrate improved self-regulation during the learning process (Bylieva et al., 2021). Thus, fostering adaptability and proactive problem-solving skills among students is pivotal in navigating technological disruptions and optimizing the learning experience, particularly in online settings.

In the domain of task strategy, the findings of this investigation reveal a notable divergence wherein students exhibit superior task strategy skills during offline learning in comparison to online modalities, as elucidated in Figure 4a and Table 1. Offline learning environments afford students the opportunity to engage in meticulous note-taking and task instruction comprehension, a practice less readily facilitated in online settings. Students who recognize the significance of comprehensive note-taking demonstrate an enhanced capacity to elevate the quality of their learning endeavors (Hapsari & Fatmasari, 2022). Moreover, students employ various strategies such as promptly addressing assignments, utilizing available templates, selecting conducive study environments, and engaging in collaborative discussions with peers. These strategies, encompassing prompt task initiation and task estimation, play a pivotal role in task completion (Brady et al., 2022). Such proactive approaches in offline learning environments contribute significantly to task efficacy and overall academic success, underscoring the importance of strategic planning and execution in optimizing the learning experience.

Certain students may still encounter challenges in devising effective strategies for completing assignments during online learning, whereas in offline learning contexts, students often develop and employ tailored strategies, drawing from past successes, to tackle assigned tasks. Leveraging previously successful strategies enables students to expedite task completion and enhance outcomes (König et al., 2015). This adaptability stems from students' capacity to acclimate to the demands of the tasks at hand (Anthonysamy, 2021), facilitating the utilization of familiar and proven strategies to navigate through assignments efficiently and effectively. Consequently, the ability to adapt and apply successful strategies underscores the importance of experiential learning in enhancing task performance, particularly in offline learning environments.

In the domain of time management, the findings of this study reveal a notable discrepancy wherein students exhibit superior time management skills during offline learning in comparison to online modalities, as depicted in Figure 4a and Table 1. Offline learning environments afford students the structure and routine conducive to effective time allocation for studying, completing assignments, and exam preparation. However, despite perceiving more available free time in online learning settings, students often struggle to optimize this time resourcefully. Rather than dedicating their free time to learning-related activities, students frequently engage in non-academic pursuits such as household chores, gaming, or socializing with friends. This perceived surplus of free time often leads to procrastination in assignment completion, undermining students' time management proficiency (Pelikan et al., 2021). Nevertheless, effective time management remains indispensable for student success (Wolters et al., 2017), and the lack of discipline in managing time can deleteriously impact self-regulatory abilities (Barak et al., 2016). Moreover, educators play a crucial role in facilitating time management skills by providing task-based time estimates, thereby promoting discipline and reducing procrastination tendencies among students (Häfner et al., 2014). Collaborative efforts between students and educators are thus essential in fostering effective time management practices conducive to academic success.

In the realm of time management, disparities exist between online and offline learning environments concerning students' ability to estimate the workload required for assignments. While offline learners meticulously outline the estimated time needed for tasks, especially those perceived as challenging or time-consuming, online students often neglect this critical aspect. Establishing accurate time estimates holds paramount importance for task completion, particularly for complex assignments (Brady et al., 2022). Furthermore, adept time management correlates positively with enhanced self-regulation abilities (Khat, 2022; Usroh et al., 2022), underscoring the significance of this skill in fostering academic success.

Additionally, offline learners demonstrate the ability to allocate specific study periods for exam preparation, a practice less common among online learners who may rely on the accessibility of course materials during examinations. However, dedicating dedicated study time prior to exams yields superior performance outcomes (Hsu et al., 2023), highlighting the importance of structured study habits even in online learning contexts. Thus, instilling effective time management practices, including accurate workload estimation and dedicated study time allocation, is essential for optimizing learning outcomes across both online and offline modalities.

In the domain of persistence, the findings of this study reveal a significant disparity wherein students demonstrate superior persistence levels during offline learning compared to online modalities, as illustrated in Figure 4a and Table 1. Offline learning environments foster a conducive atmosphere for maintaining motivation and concentration, enabling students to sustain their commitment to learning. Offline learners frequently exhibit self-motivation, driven by their overarching learning goals and aspirations to fulfill their educational objectives (Gabi & Sharpe, 2021; Xuereb, 2014). When faced with moments of boredom or distraction during offline learning, students proactively employ strategies to refocus their attention and reignite their motivation to continue learning.

Conversely, online learning environments present challenges in maintaining persistence, with students often succumbing to distractions such as social media, gaming, and messaging applications, thereby diluting their focus on academic pursuits. In such scenarios, exercising self-control becomes paramount to mitigate distractions and maintain focus on learning objectives (Yang et al., 2023). Moreover, cultivating intrinsic motivation to sustain focus on learning emerges as a critical factor (Mahmud & German, 2021), fostering a sense of commitment towards achieving preset learning goals (Özidal et al., 2022). Thus, fostering persistence in online learning necessitates the cultivation of effective self-regulatory mechanisms and intrinsic motivation to mitigate distractions and sustain focus on academic endeavors, ultimately enhancing learning outcomes.

In the realm of student involvement, offline learning environments typically foster active engagement and enthusiasm among students, whereas the absence of direct involvement in online learning often leads to feelings of boredom and passivity. The lack of direct engagement diminishes students' enthusiasm and propensity to actively participate in the learning process (Muljana & Luo, 2019). Additionally, the absence of innovative learning approaches further exacerbates this issue, undermining students' motivation to learn (Yunus et al., 2023). Thus, it becomes imperative for educators to cultivate student interest in learning, such as by incorporating discussions on relevant and contemporary material. Providing students with the latest material not only piques their interest but also stimulates their motivation to learn (Au et al., 2018), fostering a positive learning environment conducive to active engagement and enhanced learning outcomes.

In the realm of help-seeking behavior, the study findings indicate that students exhibit a superior ability to seek assistance during offline learning compared to online modalities, as illustrated in Figure 4a and Table 1. The primary driver behind students' enhanced ability in offline environments is attributed to heightened communication channels with peers and instructors. Offline learning environments facilitate increased peer-to-peer interactions (Yen et al., 2018) and student-instructor interactions (Kite et al., 2020), which students leverage to seek help effectively when encountering learning difficulties. Engaging in communication and seeking assistance from peers not only enhances students' self-regulation skills (Alvi & Gillies, 2015; Dunn et al., 2014) but also expedites task completion through guidance from instructors (Gabi & Sharpe, 2021).

Conversely, in online settings, students may feel less familiar and confident in engaging socially, which can impede their ability to seek help effectively. Nonetheless, actively seeking assistance, particularly from peers, holds significant benefits for learning outcomes (García-Rodicio et al., 2013; Wandler & Imbriale, 2017). The scarcity of peer communication channels may contribute to reduced self-regulation skills among online learners (Gonida et al., 2019). Thus, fostering effective communication channels and promoting peer assistance is essential for facilitating help-seeking behavior and enhancing self-regulation skills in both offline and online learning environments.

In addition to seeking assistance from peers, students frequently turn to lecturers and subject matter experts within their academic institution when encountering challenges with course material. During offline learning, students often rely on direct interactions with lecturers to gain deeper insights into the material. However, in online learning environments, students may hesitate to seek help from lecturers, particularly outside of designated learning hours. Despite this reluctance, access to lecturer assistance is crucial for fostering a comprehensive understanding of the material (Thomas & Tagler, 2019). Lecturers play a pivotal role in providing additional guidance and allocating extra time for students struggling to grasp complex concepts. The facilitation of communication channels between students and lecturers not only enhances students' understanding but also cultivates their self-regulation skills (Mahmud & German, 2021; Schwam et al., 2021). Thus, encouraging and facilitating student-lecturer communication is essential for promoting academic success and self-regulated learning in both offline and online educational settings.

In the domain of self-evaluation, the study findings indicate that students exhibit superior self-evaluation skills during offline learning in comparison to online modalities, as depicted in Figure 4a and Table 1. Although students acknowledge the importance of self-evaluation, they tend to engage in self-assessment more frequently during offline learning sessions. This self-assessment practice plays a fundamental role in individuals' ability to self-regulate (Panadero et al., 2018; Ritchie, 2016) and is instrumental in reflecting on their learning journey, as well as identifying strengths and weaknesses (Yan, 2020). Offline learners often seek assistance from peers to aid in their self-evaluation process, whereas some online learners rely solely on self-assessment without seeking input from peers. However, peer-assisted evaluation can significantly accelerate the development of students' self-regulation skills (Bernard & Kermarrec, 2022), emphasizing the importance of collaborative learning environments in fostering effective self-evaluation practices. Thus, promoting peer-assisted self-evaluation and encouraging frequent self-assessment are essential for enhancing self-regulation skills and fostering academic success across both offline and online learning contexts.

Indeed, some students may perceive self-evaluation as more crucial than peer evaluation due to concerns about peers' judgment and a sense of solidarity that fosters positivity (Suñol et al., 2016). In response to this, the role of lecturers becomes pivotal in facilitating self-evaluation processes among students. Lecturers can play a proactive role in nurturing students' self-evaluation skills through various means, such as implementing self-assessment activities or structured peer assessments. By incorporating these strategies into the curriculum, lecturers can stimulate students' self-evaluation abilities, thereby fostering the development of robust self-regulation skills (Panadero et al., 2017). Providing opportunities for self-assessment and structured peer assessments not only empowers students to evaluate their own progress but also encourages them to critically reflect on their learning experiences. Thus, by leveraging these instructional approaches, lecturers can effectively cultivate students' self-regulation skills and promote their academic success.

The findings of the second research objective reveal a positive correlation between student self-regulation abilities in both online and offline learning contexts, as illustrated in Figure 6 and Table 2. This indicates that enhancements in students' self-regulation skills during online learning correspond to improvements in their self-regulation abilities during offline learning, and vice versa. Online learning platforms afford students the flexibility to cultivate and refine their self-regulation skills. As students adeptly develop their self-regulation skills in online environments, they become accustomed to discipline and exhibit reduced tendencies for procrastination in completing assignments during offline learning (Barak et al., 2016; Pelikan et al., 2021). Moreover, students who successfully employ certain task strategies in online learning often leverage these previously effective strategies when faced with tasks in offline learning settings. Additionally, the focused attention and enthusiasm demonstrated by students in online learning contribute to their readiness to tackle challenging tasks in offline learning, as they have been primed and trained through their online learning experiences (Turan et al., 2022). Thus, the reciprocal relationship between self-regulation abilities in online and offline learning underscores the interconnectedness of these skills and highlights the potential for cross-contextual transfer and enhancement of self-regulatory competencies.

Students who autonomously boost their motivation and demonstrate high persistence levels during online learning are likely to find the transition to offline learning smoother, particularly when offline learning environments offer greater external motivation compared to online settings. Additionally, students tend to feel more motivated when learning materials are relevant, current, and presented in an engaging manner. Such learning experiences stimulate student motivation during online sessions, prompting them to eagerly participate in offline classes to sustain or augment their motivation for continued learning (Stoian et al., 2022). This heightened motivation serves as a valuable asset for students, enabling them to engage in learning activities to the best of their abilities (Özdal et al., 2022). Thus, fostering intrinsic motivation and persistence, coupled with providing stimulating and relevant learning materials, plays a pivotal role in facilitating seamless transitions between online and offline learning environments while enhancing overall student engagement and learning outcomes.

Students who frequently engage with peers and instructors during online learning are more likely to feel comfortable interacting socially and seeking assistance when faced with challenges in offline learning environments. Interactions such as seeking guidance from lecturers in online settings can positively impact students' self-confidence when transitioning to offline learning (Othman, 2021). Conversely, students who lack positive interactions during offline learning may feel awkward and less confident when participating in face-to-face learning sessions (Firman et al., 2023). Recognizing the significance of social interaction in online learning, it is essential for instructors to leverage various interactive platform features to facilitate robust interaction among students and between students and instructors (Zheng et al., 2021). By fostering meaningful interactions in online learning environments, instructors can help students develop the necessary social skills and confidence to effectively engage in offline learning activities, thereby promoting a supportive and conducive learning environment across both modalities.

The findings of the third research objective indicate a positive relationship between self-regulation and learning outcomes, both in online and offline learning contexts, albeit with a modest correlation, as illustrated in Figure 7 and Table 3. This suggests that as students' self-regulation skills improve, their learning outcomes also tend to increase, and vice versa, as reported by Chou et al. (2023) and Wu et al. (2023). Students with effective self-regulation skills typically engage in thorough planning and preparation prior to commencing their learning activities. This proactive self-preparation is instrumental in optimizing learning outcomes (Christmann, 2017; Lin & Dai, 2022). Furthermore, students establish and monitor their learning objectives before initiating the learning process, either independently or with academic guidance. Those who effectively maintain their learning goals and provide positive feedback on their learning progress are more likely to achieve favorable learning outcomes (Honicke et al., 2020). Thus, nurturing and enhancing students' self-regulation skills is crucial for fostering academic success and maximizing learning outcomes across both online and offline learning modalities.

During the course of learning, students are confronted with various tasks, particularly in disciplines like biology where assignments such as practicums and projects often demand substantial time investments. To navigate these tasks effectively, students employ specialized strategies and time management techniques. The utilization of these tailored strategies significantly influences the timely completion of assignments, consequently impacting the learning outcomes achieved (Muljana et al., 2023). Moreover, students' ability to self-regulate in terms of time management and creating conducive learning environments plays a pivotal role in enhancing learning outcomes (Kassab et al., 2015). Additionally, the persistence demonstrated by students in diligently completing tasks to the best of their abilities also correlates positively with favorable learning results (Kassab et al., 2015; Martin et al., 2022). Therefore, by integrating effective time management strategies, fostering conducive learning environments, and promoting persistence, educators can empower students to optimize their learning experiences and achieve positive learning outcomes in biology and other academic disciplines.

Throughout the process of learning, students engage in evaluations at various stages with the goal of maximizing learning outcomes across all courses. Self-evaluation of one's self-regulation abilities plays a crucial role in enhancing student academic achievement (Yan, 2020). However, improving academic success is not solely the responsibility of individual students, it also involves collaborative efforts

from peers, lecturers, and university policies. Comprehensive support from these various stakeholders is essential for fostering the development of self-regulation skills during the learning process, ultimately contributing to improved academic success (Lee et al., 2019; Wong et al., 2019). By promoting a supportive and inclusive learning environment and providing resources and guidance, educators and university policies can empower students to enhance their self-regulation abilities and achieve academic excellence.

CONCLUSION

In summary, this study yields three key conclusions. Firstly, it establishes that offline self-regulation surpasses online self-regulation capabilities significantly. Secondly, it underscores the influential role of student self-regulation during online learning in shaping the development of self-regulation skills for offline learning, demonstrating a robust correlation between the two. Lastly, while the correlation is deemed weak, the study highlights the discernible impact of student self-regulation abilities on enhancing overall learning outcomes.

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AUTHOR CONTRIBUTIONS

AKR initiated the study idea, designed the research methods, conducted the statistical analysis, and wrote the manuscript. DL contributed in supervising the project, reviewing and revised the manuscript critically for important intellectual content; FR contributed in supervision for the project; YA contributed in reviewing and improving the writing of the manuscript. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest in respect to the research, authorship, and/or publication of this article.

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