



MOBILE APPLICATION ADOPTION AND SELF-REGULATED LEARNING IN CHEMISTRY INSTRUCTION: PATHWAYS TO ENHANCED ENGAGEMENT AND AUTONOMY IN GENERAL CHEMISTRY

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ABSTRACT

This study examines the relationship between mobile application adoption and self-regulated learning (SRL) among senior high school students enrolled in General Chemistry. Guided by the Technology Acceptance Model (TAM) and Zimmerman's Self-Regulated Learning Theory, the study examined the associations between students' perceived usefulness and ease of use of mobile applications and their self-regulated learning practices. The study used a descriptive-correlational design involving 87 STEM students. Data were collected using adapted questionnaires on mobile application adoption and self-regulated learning and analyzed using descriptive statistics and Pearson product-moment correlation. Results showed that students reported high levels of mobile application adoption, particularly in terms of perceived usefulness and perceived ease of use. Likewise, students demonstrated high levels of self-regulated learning across all dimensions, with engagement obtaining the highest mean score. Mobile application adoption was positively and significantly associated with all self-regulated learning dimensions. Perceived usefulness exhibited the strongest association with self-efficacy, while perceived ease of use showed its strongest association with self-efficacy. Based on the findings, an Independent Learning Plan (ILP) for General Chemistry was developed to support students' goal setting, self-monitoring, self-reflection, engagement, and self-efficacy. The findings suggest that students who perceive mobile applications as useful and easy to use tend to report stronger self-regulated learning practices. However, the study was limited by its relatively small sample size, reliance on self-reported data, and descriptive-correlational design, which precludes causal inferences. Future research may use larger, more diverse samples, employ predictive analytical techniques, and evaluate the effectiveness of the proposed ILP.

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INTRODUCTION

The increasing integration of mobile technology in education has transformed how students access, engage with, and manage learning. Mobile learning enables students to study anytime and anywhere through smartphones, tablets, and other portable devices, providing flexible access to educational resources (Crompton

et al., 2020). Mobile learning has also increasingly been examined as a means of supporting students' independent and self-regulated learning processes (Palalas & Wark, 2020; Baars & Viberg, 2022). Recent reviews and empirical studies also indicate that mobile learning can give learners flexible opportunities to manage learning activities, monitor progress, and access academic resources beyond conventional classroom settings (Hartley et al., 2020; Nyirenda & Simuja, 2023; Ubben et al., 2023).

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In Chemistry education, mobile applications have been used to provide interactive learning experiences that can support students' engagement, motivation, and learning of chemistry concepts (Cahyana et al., 2017). Mulyani et al. (2016) demonstrated the use of ICT-based media in Chemistry learning to develop students' generic science skills, providing evidence of the instructional value of technology-supported Chemistry learning. Studies have demonstrated the use of mobile applications for chemistry learning through mobile games, augmented-reality visualization, Android-based learning applications, and other interactive digital resources (Jones et al., 2018; Aw et al., 2020; Ewais et al., 2021; Kurniawan et al., 2022). For example, Wardani et al. (2017) developed an Android-system-based Chemistry board game using an inquiry approach, illustrating how mobile technologies can combine interactive learning activities with Chemistry content. The broader literature on mobile science education similarly indicates that mobile applications can support interactive, accessible, and learner-centered science learning experiences (Tavares et al., 2021; Ubben et al., 2023).

Beyond facilitating access to content, mobile applications may support the development of self-regulated learning (SRL), which refers to learners' ability to actively control and manage their cognitive, motivational, and behavioral processes during learning (Zimmerman, 2000). In a review of major SRL models, Panadero (2017) emphasized that SRL encompasses interconnected cognitive, metacognitive, motivational, behavioral, and affective processes and commonly involves goal setting, monitoring, control, and reflection. Self-regulated learners employ strategies such as goal setting, self-monitoring, self-reflection, and self-evaluation to achieve academic objectives. These skills have been associated with improved academic performance, persistence, and independent learning (Raković et al., 2022).

In science education, Atmojo et al. (2020) documented the relevance of self-regulated learning and self-awareness in students' science learning, highlighting the importance of learners actively regulating their learning processes. Further evidence comes from Lobos et al. (2021), who developed and evaluated the 4Planning mobile application as part of an intra-curricular program designed to facilitate self-regulated learning competencies among university students. Their quasi-experimental findings indicated significant differences in SRL between students exposed to the program and those in the control group. Research on mobile-supported learning has similarly

shown that mobile technologies can support self-regulatory processes by giving learners opportunities to plan, monitor, evaluate, and manage their learning activities (Zheng et al., 2018; Palalas & Wark, 2020).

Many educational mobile applications incorporate features such as progress tracking, reminders, immediate feedback, and personalized learning pathways that may encourage the development of these self-regulatory behaviors (Baars & Viberg, 2022). Empirical research has also linked students' use of mobile applications to self-regulated learning processes, including using learning strategies and monitoring learning progress (Baars et al., 2022). Studies examining mobile-supported learning have likewise reported relationships with students' self-regulation, planning, monitoring, and independent learning behaviors (Jaramillo et al., 2022; Nurdin et al., 2023; Zang & Shen, 2024). Likewise, Boroughani et al. (2023) demonstrated the relevance of mobile-device-supported learning to students' self-regulatory processes, providing further evidence that mobile learning environments may help learners manage their academic activities.

The Technology Acceptance Model (TAM) provides a useful lens for understanding why students choose to adopt educational technologies. According to Davis (1989), perceived usefulness and perceived ease of use primarily influence technology acceptance. Subsequent mobile-learning research has extended TAM by examining how system and information characteristics relate to users' perceptions and continued intention to use mobile learning technologies (Al-Emran et al., 2020). Previous studies show that students are more likely to embrace mobile learning tools when they believe these technologies are beneficial and easy to use (Al-Rahmi et al., 2020). Studies applying technology-acceptance frameworks to mobile learning have likewise examined perceived usefulness, perceived ease of use, behavioral intention, and related factors as explanations for students' adoption of mobile technologies (Aliaño et al., 2019; Zhonggen & Xiaozhi, 2019; Chand et al., 2022).

These perceptions may affect not only technology adoption but also self-regulated learning behaviors. In particular, integrating technology acceptance and self-regulated learning constructs has been proposed as a useful approach to understanding students' engagement with technology-supported learning environments (Barz et al., 2024). When students view mobile applications as valuable learning resources, they may be more motivated to plan, monitor,

and evaluate their learning activities. This intersection is particularly relevant because students' willingness to use technology and their ability to regulate learning through it represent related but conceptually distinct dimensions of technology-supported learning (Baars & Viberg, 2022; Barz et al., 2024).

Recent studies have reported positive relationships between mobile learning environments and various aspects of SRL, including learner autonomy, metacognitive monitoring, engagement, and self-efficacy (Palalas & Wark, 2020; Breitwieser et al., 2023). Zheng et al. (2018) reported improvements in students' self-regulated learning skills after implementing a mobile self-regulated learning application. Baars et al. (2022) examined students' actual use of a mobile application specifically designed to support self-regulated learning processes. Similarly, Benzon et al. (2024) found that a chemistry mobile game application enhanced students' self-regulation and self-efficacy. Research has also examined mobile learning games and applications as mechanisms for supporting self-regulatory behaviors, although outcomes and contexts vary across studies (Nurdin et al., 2023; Zang & Shen, 2024).

The chemistry-specific literature further shows that mobile applications can support learning through interactive, independent learning experiences, including organic chemistry applications, Android-based chemistry applications, and mobile visualization tools (Ping et al., 2018; Fonseca et al., 2021; Kurniawan et al., 2022; Lau et al., 2022). Notably, Lau et al. (2022) examined a mobile visualization application within a first-year General Chemistry course, providing direct evidence of mobile-app use within the disciplinary context of the present study. Similarly, Wardani et al. (2017) demonstrated the application of an Android-based Chemistry board game for inquiry-oriented learning, while Saffkolam and Sinchai (2026) examined a Chemistry learning game among Grade 12 students, providing more recent evidence of mobile-supported Chemistry learning at the senior high school level. These studies show the range of ways mobile technologies have been incorporated into Chemistry learning, while also highlighting the need to examine how students perceive and use these technologies in relation to their broader learning practices.

While these findings demonstrate the potential of mobile applications to support independent learning, existing research has focused largely on academic achievement, motivation, and general technology acceptance. Less attention has been given to how mobile application

adoption relates to specific dimensions of self-regulated learning, particularly within Chemistry education. Moreover, much of the chemistry-related mobile-learning literature has examined the effectiveness or development of particular applications rather than students' existing adoption levels across different educational applications. Although mobile-SRL research has expanded, systematic reviews continue to indicate the need for further investigation into how mobile learning environments relate to distinct self-regulatory processes and learner characteristics (Nyirenda & Simuja, 2023). Similarly, studies such as Hartley et al. (2020) and Jaramillo et al. (2022) demonstrate the relevance of mobile technology to self-regulation but do not specifically address students' perceived usefulness and perceived ease of use across multiple Chemistry-related applications.

Furthermore, studies examining these relationships among senior high school STEM students in the Philippine context remain limited. Although studies have examined mobile learning, chemistry applications, and self-regulated learning in various educational settings, the intersection of these variables within the Philippine senior high school STEM context remains insufficiently documented. Existing literature on mobile science and Chemistry learning largely comes from contexts outside Philippine senior high schools, making a context-specific investigation important for understanding how learners perceive and use mobile technologies in General Chemistry (Premthaisong et al., 2019; Tavares et al., 2021; Ubben et al., 2023). Understanding how students' perceptions of mobile applications relate to different SRL components may provide valuable insights for designing effective technology-supported Chemistry instruction.

Therefore, this study examined the relationship between mobile application adoption and self-regulated learning among senior high school students enrolled in General Chemistry. Guided by the Technology Acceptance Model and Zimmerman's Self-Regulated Learning Theory, the study examined how perceived usefulness and perceived ease of use relate to students' goal setting, self-monitoring, self-reflection, engagement, and self-efficacy. The findings may contribute to developing learner-centered Chemistry instruction that effectively integrates mobile technologies to support independent learning.

To achieve these objectives and address the identified gaps in the literature, the study sought to answer the following research questions:

1. What is the degree of mobile application adoption among senior high school students in learning General Chemistry in terms of:
 - a. perceived usefulness; and
 - b. perceived ease of use?
2. What is the extent of self-regulated learning (SRL) practices among senior high school students learning General Chemistry in terms of:
 - a. goal-setting;
 - b. self-monitoring;
 - c. self-reflection;
 - d. engagement; and
 - e. self-efficacy?
3. Is there a significant relationship between the degree of mobile application adoption and the extent of self-regulated learning (SRL) practices among senior high school students in General Chemistry?
4. What independent learning plan may be developed based on the findings of the study to support self-regulated learning and engagement skills among senior high school students in General Chemistry?

METHODS

This study employed a quantitative, descriptive-correlational research design to examine the relationship between mobile application adoption and self-regulated learning among senior high school students enrolled in General Chemistry. A descriptive-correlational design was appropriate because it allows the researcher to describe variable levels and determine the strength and direction of relationships without manipulating conditions or introducing interventions (Creswell & Creswell, 2018; Fraenkel et al., 2012). The study did not seek to establish causal relationships, determine effectiveness, or measure one variable's influence on another. Rather, it focused on identifying statistically significant associations between students' perceptions of mobile applications and their self-regulated learning practices.

Because the study used a descriptive-correlational design, it aimed only to describe the levels of mobile application adoption and self-regulated learning and to determine whether statistically significant relationships existed between these variables. The design does not permit conclusions regarding causation, influence, effectiveness, or predictive effects. Therefore, the authors interpreted all findings as associations among variables rather than evidence that mobile application adoption causes changes in self-regulated learning practices.

The study followed the Technology Acceptance Model (TAM) (Davis, 1989), which explains technology adoption through perceived usefulness and perceived ease of use, and Zimmerman's Self-Regulated Learning Theory (Zimmerman, 2000), which emphasizes learners' active regulation of cognitive, motivational, and behavioral processes. TAM aligns with research on students' acceptance and adoption of mobile learning technologies, where perceived usefulness and perceived ease of use are commonly examined as central technology-acceptance constructs (Aliaño et al., 2019; Zhonggen & Xiaozhi, 2019; Chand et al., 2022). Similarly, mobile learning has been linked conceptually and empirically to self-regulated learning processes, particularly learners' active management of their learning activities and strategies (Palalas & Wark, 2020; Baars & Viberg, 2022). Recent empirical work has further examined the relationship between mobile learning and self-regulation, including the use of mobile applications to support planning, monitoring, and learning management (Jaramillo et al., 2022; Nurdin et al., 2023; Zang & Shen, 2024). Specifically, the study investigated the relationship between students' perceptions of mobile applications and their self-regulated learning practices in General Chemistry.

The study participants were senior high school students enrolled in General Chemistry under the Science, Technology, Engineering, and Mathematics (STEM) strand during the Academic Year 2024-2025. Researchers selected participants using total enumeration sampling. Eligibility criteria included current enrollment in General Chemistry and experience using mobile applications for educational purposes.

The sample size was determined based on the number of eligible students available during the data collection period. While the sample provided sufficient data to examine relationships among the study variables and interpret the findings in the context of the selected participants, it cannot be generalized to all senior high school students.

To provide context on students' exposure to mobile learning technologies, respondents reported how often they used mobile applications for learning and their familiarity with chemistry-related mobile applications. Results showed that 65 of 87 respondents used mobile applications daily or almost daily for learning, 20 reported weekly use, and only 2 reported rare use. No respondent indicated never using mobile learning applications.

Students reported familiarity with a variety of chemistry-related applications, including Periodic Table, Khan Academy, Socratic by Google, Molecule 3D, Chemistry, MEL Chemistry VR Lessons, Happy Atoms, and Chemistry Textbook applications. Because the study focused on students' perceptions of mobile learning technologies rather than a specific application, participants were not required to use the same mobile application. Mobile application use reflected both school-related and independent learning experiences.

Data were collected using a structured questionnaire consisting of two major sections: the Mobile Application Usage Scale and the Self-Regulated Learning Questionnaire. The Mobile Application Usage Scale consisted of two subscales: Perceived Usefulness (12 items) and Perceived Ease of Use (15 items). The instrument was adapted from the Technology Acceptance Model (TAM) instruments developed by Shukla and Sharma (2018), Kim and Garrison (2009), and Asunka (2020), with modifications to align with the General Chemistry context. Selecting perceived usefulness and perceived ease of use as the principal dimensions aligns with the original TAM and subsequent applications of the model to mobile learning adoption (Davis, 1989; Aliaño et al., 2019; Chand et al., 2022). These dimensions have also been widely examined in studies of mobile learning adoption, providing a basis for examining students' perceptions of the usefulness and usability of mobile learning technologies (Al-Rahmi et al., 2020; Zhonggen & Xiaozhi, 2019).

Sample items for Perceived Usefulness included: *"Mobile apps help me understand chemistry concepts more effectively"* and *"Mobile apps allow me to access learning materials anytime and anywhere."*

Sample items for Perceived Ease of Use included: *"Mobile apps are easy to navigate and use"* and *"I can use mobile apps without needing technical assistance."*

The Mobile Application Usage Scale measured students' perceptions of mobile application usefulness and ease of use based on the Technology Acceptance Model. It did not measure actual application usage behavior, frequency, or duration.

The Self-Regulated Learning Questionnaire was adapted from Pintrich & De Groot's (1990) Motivated Strategies for Learning Questionnaire (MSLQ). The instrument measured five dimensions: Goal Setting, Self-Monitoring, Self-Reflection, Engagement, and Self-Efficacy. Including these dimensions reflects the broader conceptualization of self-regulated learning as involving

learners' cognitive, motivational, and behavioral regulation during learning (Zimmerman, 2000). Research on mobile-supported SRL likewise emphasizes learners' active monitoring, regulation, and reflection in managing their learning processes (Zheng et al., 2018; Baars et al., 2022). The use of multiple SRL dimensions is also consistent with recent mobile-learning research that examines self-regulation as a multidimensional process involving planning, monitoring, engagement, and learner management (Hartley et al., 2020; Nyirenda & Simuja, 2023).

The questionnaire assessed five dimensions of self-regulated learning, namely goal setting, self-monitoring, self-reflection, engagement, and self-efficacy. Goal setting refers to students' ability to establish learning objectives and formulate plans to achieve them. Self-monitoring pertains to students' capacity to track, assess, and regulate their learning progress. Self-reflection involves evaluating learning experiences, outcomes, and strategies used during the learning process. Engagement refers to students' active participation, effort, and involvement in learning activities, while self-efficacy pertains to students' confidence in their ability to perform academic tasks and overcome learning challenges. The Self-Regulated Learning Questionnaire assessed students' self-reported SRL practices and perceptions rather than direct observations of learning behavior or academic achievement.

Responses were measured using a four-point Likert scale. Higher scores indicated higher perceived mobile application adoption and higher levels of self-regulated learning practices.

Content validity was established through expert review. Three experts independently evaluated the questionnaire for relevance, clarity, appropriateness, and alignment with the theoretical constructs. The panel consisted of a senior chemistry educator, a science curriculum specialist, and a quantitative educational researcher. The researchers incorporated the validators' recommendations into the final instrument before pilot testing. Although formal Content Validity Index (CVI) statistics were not computed, the expert review process provided evidence of content adequacy and alignment with the study objectives. Expert validation is widely recommended to ensure that an instrument adequately represents the constructs being measured (Polit & Beck, 2006).

A pilot test was conducted among students from a school not included in the study to assess the instrument's clarity, suitability, and reliability. Reliability was evaluated using Cronbach's alpha coefficient. Cronbach's alpha is a commonly used

measure for determining scale reliability and internal consistency in survey research (Taber, 2018). Table 1 presents the reliability coefficients for each construct.

Table 1. Reliability Coefficients of the Research Instrument

Instrument Section	Cronbach's Alpha	Interpretation
Perceived Usefulness	0.845	High Internal Consistency
Perceived Ease of Use	0.889	Excellent Reliability
Goal Setting	0.847	High Internal Consistency
Self-Monitoring	0.840	High Internal Consistency
Self-Reflection	0.758	Acceptable Reliability
Engagement	0.838	High Internal Consistency
Self-Efficacy	0.899	Very High Internal Consistency
Overall Reliability	0.845	High Overall Reliability

The reliability coefficients ranged from 0.758 to 0.899, indicating acceptable to excellent internal consistency across all dimensions. The overall reliability coefficient of 0.845 suggests that the instrument was sufficiently reliable for measuring mobile application adoption and self-regulated learning. The study did not collect information regarding duration of mobile application use, length of exposure to specific applications, or whether application use was teacher-directed or voluntary. Consequently, the findings should be interpreted as reflecting students' general perceptions of educational mobile applications rather than experiences with specific mobile learning platforms.

Reliability analysis yielded acceptable to excellent Cronbach's alpha coefficients across all dimensions, indicating satisfactory internal consistency. However, the study did not formally assess construct validity through Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA). The study supported construct validity by adapting measurement instruments from established theoretical frameworks and previously validated studies, specifically the Technology Acceptance Model (TAM) and the Motivated Strategies for Learning Questionnaire (MSLQ). Future research with larger samples is recommended to conduct factor-analytic procedures and provide stronger evidence of construct validity.

Before data collection commenced, permission was secured from the school administration, and ethical approval was obtained from the University Research Ethics Board of Saint Mary's University under UREB Code 2025-0876. To minimize potential coercion and ensure objectivity, a research assistant who was not involved in student evaluation administered the questionnaires. This approach reduced the possibility of power-related influence between the teacher-researcher and student participants.

An orientation session was conducted to explain the study objectives, procedures, confidentiality protocols, and participants' rights. Consent and assent forms were collected, including parental or guardian consent for minor participants. The validated questionnaires were distributed during General Chemistry class periods, and students were given approximately 15–20 minutes to complete the survey. Upon completion, questionnaires were immediately collected, checked for completeness, and securely stored.

Survey responses were encoded, organized, and analyzed using the Statistical Package for the Social Sciences (SPSS).

To address the research objectives, several statistical techniques were employed. Mean and standard deviation were computed to determine: (1) the degree of mobile application adoption in terms of perceived usefulness and perceived ease of use, and (2) the extent of SRL practices in terms of goal setting, self-monitoring, self-reflection, engagement, and self-efficacy. These measures are appropriate for summarizing Likert-scale responses and describing participant perceptions (Pallant, 2020).

To determine the relationship between mobile application adoption and SRL components, Pearson's Product-Moment Correlation Coefficient (Pearson r) was utilized. Pearson correlation is a widely used statistical technique for measuring the strength and direction of relationships between continuous variables (Field, 2013; Pallant, 2020). The significance level was set at 0.05, and the correlation coefficients were interpreted according to Cohen's (1988) effect size guidelines: small ($r = .10-.29$), moderate ($r = .30-.49$), and strong ($r \geq .50$). Before conducting the correlation analysis, we assessed assumptions of normality and linearity to ensure Pearson's r was appropriate, following established statistical procedures (Field, 2013).

RESULTS AND DISCUSSION

Table 2 presents the degree of mobile application adoption among senior high school students in learning General Chemistry.

Table 2. Degree of Mobile Application Adoption in Learning General Chemistry

Factor	Mean	SD	QD
Perceived Usefulness	3.38	.402	High
Perceived Ease of Use	3.20	.482	High

The findings indicate that senior high school students perceive mobile applications as both useful and easy to use in learning General Chemistry. High ratings across both dimensions suggest that learners recognize the educational value of mobile applications not only as tools for accessing information but also as mechanisms that help them understand complex scientific concepts. This finding aligns with studies showing that chemistry-related mobile applications can provide learners with interactive, visual, and accessible resources that support learning of abstract chemistry concepts (Ping et al., 2018; Ewais et al., 2021; Kurniawan et al., 2022; Lau et al., 2022).

These findings also align with the broader literature on technology-supported Chemistry learning. Mulyani et al. (2016) reported using ICT-based media to support Chemistry learning and students' generic science skills, while Wardani et al. (2017) demonstrated how an Android-based Chemistry board game could be incorporated into inquiry-oriented learning. More recently, Safkolam and Sinchai (2026) examined a Chemistry learning game among Grade 12 students, further illustrating the continued development of technology-mediated Chemistry learning resources for senior high school learners. These studies provide contextual support for the present finding that students recognize the educational utility of mobile technologies, although the current study specifically measured perceived usefulness and perceived ease of use rather than the effectiveness of individual applications.

The results describe students' perceptions of mobile application usefulness and ease of use rather than actual mobile application adoption behavior. Therefore, the findings are interpreted within the context of technology acceptance rather than actual usage metrics. This distinction aligns with the Technology Acceptance Model, in which perceived usefulness and perceived ease of use reflect users' perceptions of technology acceptance rather than direct measures of actual usage behavior (Davis, 1989).

The strong ratings associated with multimedia integration reinforce prior studies emphasizing the role of visual simulations and interactive tools in enhancing conceptual understanding in science education (Putra et al., 2020). Similarly, Ewais et al. (2021) emphasized that mobile learning applications integrating visual representations and simulation-based features can significantly improve learners' understanding of science concepts, particularly in disciplines characterized by abstract and multidimensional content. Research on chemistry-specific mobile applications also shows the value of interactive molecular visualization and mobile-supported representations in helping learners engage with concepts that are difficult to observe directly (Aw et al., 2020; Lau et al., 2022). Multimedia-rich learning environments therefore appear particularly beneficial in Chemistry because they turn complex, abstract ideas into more concrete, observable representations. This observation aligns with the broader use of mobile technologies in science education, where applications provide interactive and accessible learning experiences beyond conventional classroom resources (Tavares et al., 2021; Ubben et al., 2023).

Beyond their instructional utility, the high ratings for Perceived Usefulness and Perceived Ease of Use suggest that students view mobile applications not merely as supplementary technological tools but as learning supports that facilitate cognitive processing. In General Chemistry, learners often must simultaneously process macroscopic observations, symbolic notations, and submicroscopic representations, creating substantial cognitive demands. Applications perceived as easy to navigate may serve as external cognitive supports by reducing unnecessary mental effort associated with interacting with technological interfaces. Consequently, students may redirect cognitive resources toward understanding concepts and establishing meaningful conceptual connections rather than toward managing technological complexity.

The Chemistry-specific literature provides further context for this finding. Mobile applications have supported molecular visualization, game-based Chemistry learning, and virtual laboratory experiences (Jones et al., 2018; Aw et al., 2020; Lau et al., 2022). More recent work on three-dimensional mobile applications for virtual Chemistry laboratories also demonstrates how mobile technologies can provide interactive representations and simulated laboratory experiences (Aslam et al., 2025). These applications illustrate the range of learning affordances available through mobile technologies, although the present study did not evaluate the effectiveness of any particular application.

The findings further highlight an important characteristic of contemporary learners, particularly among digitally oriented generations, where familia-

rity with technology influences readiness to engage in independent learning activities.

Recent findings by Fitriati et al. (2025) suggest that perceived ease of use is positively associated with learners' enjoyment and continued use of educational technologies. When digital learning environments are intuitive and accessible, students may be more willing to engage with technology-supported learning activities. Likewise, Barz et al. (2024) argued that technology acceptance extends beyond immediate user satisfaction and may be associated with students' sustained engagement in digital learning practices and long-term learning behaviors. This interpretation is also compatible with mobile-learning adoption research emphasizing that students' perceptions of usefulness and usability are important considerations in technology acceptance (Al-Rahmi et al., 2020; Chand et al., 2022).

These findings indicate that students generally perceive mobile applications as useful and easy to use for learning General Chemistry. The results describe students' technology acceptance levels and provide contextual information for examining their relationships with self-regulated learning dimensions. However, because the study employed a descriptive-correlational design, no conclusions can be drawn regarding whether mobile application adoption improves, enhances, or influences learning behaviors. Table 3 presents the extent of self-regulated learning (SRL) practices among senior high school students in learning General Chemistry.

Table 3. Extent of Self-regulated Learning Practices in Learning General Chemistry

Component	Mean	SD	QD
Goal-Setting	3.22	.487	High
Self-Monitoring	3.26	.459	High
Self-Reflection	3.28	.399	High
Engagement	3.29	.426	High
Self-efficacy	3.19	.540	High

Results indicate that respondents demonstrated a great extent of self-regulated learning across all dimensions, with mean scores ranging from 3.19 to 3.29. Among the components, engagement obtained the highest mean score ($M = 3.29$, $SD = .426$), followed by Self-Reflection ($M = 3.28$, $SD = .399$), Self-Monitoring ($M = 3.26$, $SD = .459$), Goal Setting ($M = 3.22$, $SD = .487$), and Self-Efficacy ($M = 3.19$, $SD = .540$). Although all dimensions fell within the high interpretation category, variations among components reveal meaningful patterns in students' learning behaviors.

The findings suggest that students actively regulate and manage their learning processes while studying General Chemistry. High scores across all dimensions indicate that learners demonstrate planning, monitoring, reflective, and engagement behaviors associated with effective self-regulation. Goal setting and engagement were particularly strong, indicating that students actively participate in and assume responsibility for their academic activities. These findings are consistent with Zimmerman's (2000) conceptualization of self-regulated learning as an active process in which learners establish goals, monitor progress, and evaluate learning outcomes through interconnected learning phases.

The high level of SRL observed in the present study is also comparable with findings from science education research. Atmojo et al. (2020) examined self-regulated learning and self-awareness in science learning and emphasized the role of students' active regulation of their learning processes. Lobos et al. (2021) likewise demonstrated the potential of a structured mobile-app-supported program to facilitate SRL strategies among university students, particularly through activities involving goal setting, time planning, study organization, and productive learning behaviors. In technology-supported learning, previous studies have similarly documented opportunities for learners to plan, monitor, and manage their learning activities through mobile and digital environments (Hartley et al., 2020; Jaramillo et al., 2022; Nurdin et al., 2023). Taken together, these studies provide contextual support for examining SRL as a multidimensional learning construct in technology-supported Chemistry education. However, because the present study used a correlational rather than an experimental design, the observed relationship between mobile application adoption and SRL should not be interpreted as evidence that mobile applications caused higher SRL.

Despite generally high SRL levels, the comparatively lower self-efficacy score suggests that students may still feel uncertain about their ability to master difficult Chemistry concepts and solve complex academic tasks independently. This finding implies that while students can effectively organize and regulate their learning behaviors, they may continue to rely on external support when confronted with unfamiliar or cognitively demanding situations. This observation aligns with Bandura's (1986) assertion that self-efficacy is associated with persistence, effort, and cognitive engagement, particularly in academically demanding disciplines such as Chemistry.

The distinction between behavioral regulation and confidence is also relevant to mobile-supported SRL research. While mobile environments may provide tools for monitoring and managing learning activities, students may differ in their confidence in using those resources to overcome challenging academic tasks (Baars & Viberg, 2022; Zang & Shen, 2024). Thus, the comparatively lower self-efficacy score in the present study may warrant particular attention when designing future technology-supported Chemistry learning activities.

An important pattern also emerged regarding self-monitoring behaviors. Although students reported high levels of self-monitoring overall, this does not necessarily mean learners consistently use digital tools strategically to support their monitoring practices. Students may be aware of their learning progress but may not fully use available technological features that could strengthen metacognitive regulation and learning efficiency. This distinction matters because access to mobile technology does not automatically mean learners will use its features strategically for self-regulation; effective mobile-supported SRL depends on how learners engage with the technology and regulate their learning processes (Baars et al., 2022; Breitwieser et al., 2023).

The discrepancy between relatively high behavioral and metacognitive indicators—such as goal setting, self-monitoring, and self-reflection—and comparatively lower psychological indicators, particularly self-efficacy, reveals an important distinction in students' learning experiences. Within Zimmerman's self-regulated learning framework, goal setting occurs during the forethought phase, while monitoring and reflection are associated with the performance and self-reflection phases. Zimmerman (2000) describes these processes as interconnected components of a cyclical self-regulatory process, in which forethought influences performance and subsequent self-reflection. The findings suggest that students may successfully engage in self-regulatory behaviors but may not necessarily develop a corresponding sense of competence or mastery.

General Chemistry remains a conceptually challenging discipline that requires learners to understand abstract relationships and engage in higher-order problem-solving. Consequently, students may effectively monitor progress and complete learning tasks while still lacking confidence in independently solving unfamiliar or complex problems. This pattern suggests that behavioral engagement and psychological confidence do not always develop at the same pace.

The findings suggest that while students generally demonstrate strong self-regulated learning practices, variability across dimensions highlights opportunities for instructional enhancement. Strengthening students' confidence through scaffolded learning experiences, guided feedback, and opportunities for successful task completion may help bridge the gap between observable learning behaviors and learners' perceived capability to manage challenging academic tasks independently. Such approaches are consistent with the broader social-cognitive view that successful performance experiences, feedback, and supportive learning conditions can contribute to the development of learners' self-efficacy (Bandura, 1986).

Relationships Between the Degree of Mobile App Adoption and the Extent of Self-regulated Learning Practices in General Chemistry

Prior to conducting Pearson's product-moment correlation analysis, the assumptions of normality and linearity were examined. Normality was assessed using skewness and kurtosis statistics, and all variables fell within the acceptable range of ± 2 , indicating approximate normality. Linearity was evaluated through visual inspection of scatterplots, which demonstrated reasonably linear relationships among the study variables. These results supported using Pearson's product-moment correlation coefficient to examine the relationships between mobile application adoption and self-regulated learning practices. Assessing distributional characteristics and linearity helps determine whether Pearson's correlation is appropriate for examining associations between variables (Field, 2013; Pallant, 2020).

Table 4. Correlation Between the Degree of Mobile Application Adoption and the Extent of Self-Regulated Learning Practices in Learning General Chemistry

Test of Correlation		Goal setting	Self-Monitoring	Self-Reflection	Engagement	Self-Efficacy
Perceived Usefulness	Pearson <i>r</i>	.582*	.650*	.554*	.684*	.708*
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001
	N	87	87	87	87	87
Perceived Ease of Use	Pearson <i>r</i>	.436*	.526*	.458*	.401*	.625*
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001
	N	87	87	87	87	87

Table 4 presents the relationships between mobile application adoption and self-regulated learning (SRL) practices among senior high school students enrolled in General Chemistry. Pearson product-moment correlation analysis revealed statistically significant positive relationships between both dimensions of mobile application adoption—perceived usefulness and perceived ease of use—and all dimensions of self-regulated learning ($p < .001$).

Although correlations were statistically significant, these findings indicate associations between variables and should not be interpreted as evidence that mobile application adoption influences, predicts, or causes changes in self-regulated learning practices. Perceived usefulness demonstrated moderate to strong positive correlations with goal setting ($r = .582$), self-monitoring ($r = .650$), self-reflection ($r = .554$), engagement ($r = .684$), and self-efficacy ($r = .708$). Likewise, perceived ease of use exhibited significant positive relationships with goal setting ($r = .436$), self-monitoring ($r = .526$), self-reflection ($r = .458$), engagement ($r = .401$), and self-efficacy ($r = .625$). The strongest association was between perceived usefulness and self-efficacy, while the weakest was between perceived ease of use and engagement.

The magnitude of the correlations suggests that perceived usefulness is more strongly associated with self-regulated learning than perceived ease of use. This finding suggests that perceived usefulness is more strongly associated with self-regulated learning dimensions than perceived ease of use among the participants in this study. Students who reported higher perceived usefulness of mobile applications also tended to report higher levels of planning, monitoring, reflection, engagement, and confidence in managing their learning activities. This pattern is conceptually consistent with the Technology Acceptance Model, in which perceived usefulness represents the extent to which a person believes that using a technology enhances task performance (Davis, 1989). It also corresponds with subsequent mobile-learning research showing that perceived usefulness is an important consideration in technology acceptance (Aliaño et al., 2019; Chand et al., 2022).

The coefficient of determination (r^2) was computed to describe the proportion of variance shared between the variables. Perceived usefulness shared approximately 33.9% of its variance with goal setting, 42.3% with self-monitoring, 30.7% with self-reflection, 46.8% with engagement, and 50.1% with self-efficacy. Similarly, perceived ease of use explained approximately 19.0% of the variance in goal setting, 27.7% in self-monitoring, 21.0% in self-reflection, 16.1% in engagement, and 39.1% in self-efficacy. These values describe the proportion of variance shared between pairs of variables and should not be interpreted as

the proportion of SRL variance caused or explained by mobile application adoption. The relatively larger shared variance observed for perceived usefulness and self-efficacy indicates a stronger statistical association between these two measures within the present sample.

Among all dimensions, self-efficacy demonstrated the strongest association with both perceived usefulness and perceived ease of use. Approximately half of the variance in self-efficacy was associated with perceived usefulness ($r^2 = .501$), indicating a substantial relationship. This finding suggests that students who view mobile applications as valuable learning resources are more likely to feel confident in their ability to complete Chemistry-related learning tasks. However, because the study employed a descriptive-correlational design, these findings should be interpreted as associations rather than evidence of causation.

The strength of the association between perceived usefulness and self-efficacy is noteworthy, given previous research linking mobile-supported learning to self-regulatory and motivational processes. Studies have reported relationships between mobile learning and learner self-management, self-regulation, and related motivational characteristics (Hartley et al., 2020; Jaramillo et al., 2022; Zang & Shen, 2024). However, the present finding should not be interpreted as demonstrating that perceiving mobile applications as useful increases self-efficacy. It indicates only that the two variables were strongly associated within this sample.

An interesting pattern emerged when comparing the self-regulated learning dimensions. Although engagement obtained the highest mean score among the SRL dimensions, its relationship with perceived ease of use was the weakest ($r = .401$). This finding suggests that active participation in learning activities may depend on factors beyond technological convenience, such as instructional design, intrinsic motivation, teacher support, and prior learning experiences. This interpretation is consistent with research indicating that technology acceptance and self-regulated learning are related but distinct aspects of technology-supported learning (Barz et al., 2024). Thus, while students may find mobile applications easy to use, ease of use alone may not sustain deeper behavioral engagement.

This finding is compatible with literature suggesting that mobile technology is an enabling environment rather than a single determinant of engagement or self-regulation. Reviews of mobile learning have emphasized the importance of how technology is integrated into learning activities and the types of opportunities it provides for learner autonomy and regulation (Palalas & Wark, 2020; Nyirenda & Simuja,

2023). More recent work examining engagement in mobile learning environments has also considered engagement alongside self-regulation and learning performance (Wong et al., 2026).

Similarly, self-efficacy received the lowest mean score among the SRL dimensions, despite showing the strongest correlations with both perceived usefulness and perceived ease of use. This apparent contradiction suggests that although students generally report lower confidence than other SRL dimensions, perceptions of mobile applications remain strongly associated with variation in their confidence. In other words, students who perceive mobile applications more positively tend to report substantially higher self-efficacy than their peers. This pattern further demonstrates the strength of the observed associations between technology acceptance and self-regulated learning dimensions. This finding also aligns with research examining technology acceptance alongside self-regulated learning and learner characteristics, suggesting that technology-related perceptions and self-regulatory processes may be meaningfully interconnected (Barz et al., 2024).

These findings align with previous studies reporting positive associations between mobile learning environments and self-regulated learning behaviors (Palalas & Wark, 2020; Breitwieser et al., 2023; Benzon et al., 2024). They are also broadly consistent with empirical and review literature indicating that mobile technologies can support different aspects

of self-regulation, including planning, monitoring, engagement, and independent learning (Hartley et al., 2020; Jaramillo et al., 2022; Nurdin et al., 2023; Zang & Shen, 2024). However, this study extends the literature by showing that technology acceptance variables are differentially associated with specific self-regulated learning dimensions. In particular, perceived usefulness appears to be more strongly associated with self-regulatory behaviors than perceived ease of use, suggesting that students may prioritize educational value over convenience when integrating mobile applications into their learning practices.

Overall, the results indicate that mobile application adoption and self-regulated learning are positively associated among senior high school students studying General Chemistry. Nevertheless, the correlational nature of the study does not permit conclusions regarding influence, effect, or causality. Future studies should use regression analysis, longitudinal designs, or experimental approaches to examine predictive relationships and provide stronger evidence on the role of mobile applications in supporting self-regulated learning.

Proposed Independent Learning Plan Based on the Study's Findings

The study's findings served as the basis for developing a proposed Independent Learning Plan (ILP) for General Chemistry, as reflected in Table 5.

Table 5. Summary of the Proposed ILP for Chemistry

ILP Component	SRL Dimension Targeted	Mobile-App Strategy	Learning Activity	Expected Output	Assessment Method
Goal-Setting Templates and Planners	Goal Setting	Use of planning and scheduling applications (e.g., Google Calendar, Notion, Study Bunny)	Weekly goal setting, daily study planning, advance reading logs, weekly reflection	Weekly goals, study schedules, advance reading records, reflection entries	Goal-setting checklist, planner review, reflection evaluation
Goal-Setting Templates and Planners	Goal Setting	Use of planning and scheduling applications (e.g., Google Calendar, Notion, Study Bunny)	Weekly goal setting, daily study planning, advance reading logs, weekly reflection	Weekly goals, study schedules, advance reading records, reflection entries	Goal-setting checklist, planner review, reflection evaluation
Progress Trackers and Monitoring Logs	Self-Monitoring	Use of monitoring and productivity applications (e.g., Forest, Pomodoro Timer, Quizizz, Khan Academy)	Progress tracking, time logging, mastery checks, self-assessment activities	Progress tracker, study-time logs, mastery records	Monitoring rubric, progress evaluation, self-assessment review
Reflection Journals and Prompts	Self-Reflection	Use of digital journaling and reflection tools (e.g., Notion, Daylio, EdPuzzle)	Reflection journaling, video-based review logs, self-error analysis activities	Reflection journal, video review logs, error analysis records	Reflection rubric and journal assessment

Interactive and Real-World Learning Activities	Engagement	Use of simulations, multimedia resources, and collaborative platforms (e.g., PhET, ChemCollective, YouTube, TED-Ed, Discord, Messenger)	Interactive simulations, real-world application activities, collaborative study sessions	Simulation logs, application reflections, collaborative study reports	Performance rubric, participation log, reflection assessment
Scaffolded Problem-Solving and Success Tracking	Self-Efficacy	Use of guided tutorials and practice applications (e.g., Khan Academy, Chemistry by WAGmob, ChemCollective, Quizizz)	Guided problem walkthroughs, skill-building exercises, success tracking, motivational reflection	Problem-solving records, practice logs, success tracker entries	Problem-solving rubric, self-efficacy checklist, progress review

The plan drew on the strong positive relationships identified between students' perceptions of mobile application adoption and the dimensions of self-regulated learning, as well as the variation in mean scores across SRL components. Particular attention was given to self-efficacy, which had the lowest mean score among the self-regulated learning dimensions, while still supporting goal setting, self-monitoring, self-reflection, and engagement. Guided by the Technology Acceptance Model and Zimmerman's Self-Regulated Learning Theory, the proposed ILP incorporates mobile-supported learning activities that provide structured opportunities for students to practice self-regulated learning strategies in General Chemistry.

The proposed ILP's structure is supported by literature describing mobile learning as an environment that can facilitate planning, monitoring, reflection, and independent learning (Baars & Viberg, 2022; Palalas & Wark, 2020). Research on mobile applications has likewise shown the potential of structured, mobile-supported activities to facilitate self-regulatory processes (Jaramillo et al., 2022; Nurdin et al., 2023; Zang & Shen, 2024). Consequently, the proposed plan translates the SRL dimensions examined in the present study into specific learning activities rather than treating mobile applications solely as sources of information.

The use of simulations, multimedia resources, guided tutorials, and interactive Chemistry activities within the proposed plan is also supported by Chemistry education literature demonstrating the application of mobile technologies to visualization, game-based learning, and virtual laboratory experiences (Jones et al., 2018; Aw et al., 2020; Lau et al., 2022). The inclusion of virtual and three-dimensional learning experiences also aligns with recent work demonstrating the use of mobile applications for virtual Chemistry laboratory environments (Aslam et

al., 2025). These technologies illustrate the types of learning affordances that may be incorporated into an independent-learning framework.

The proposed Independent Learning Plan operationalizes the five dimensions of self-regulated learning examined in the study by integrating mobile-supported activities that encourage planning, monitoring, reflection, engagement, and confidence-building in General Chemistry. The activities were selected based on the study findings, particularly the significant associations between students' perceptions of mobile application adoption and self-regulated learning dimensions, as well as the comparatively lower self-efficacy scores observed among the participants.

The ILP represents a proposed instructional output derived from the study findings. Although the plan was developed on theoretical and empirical foundations, the present study did not implement it, pilot-test it, validate it with experts, or empirically evaluate it. Therefore, no conclusions can be drawn regarding its effectiveness, usability, or impact on students' self-regulated learning or academic performance. Future research should subject the ILP to content validation, pilot implementation, and effectiveness evaluation before broader educational use.

Several limitations should be considered when interpreting this study's findings. First, the study involved 87 senior high school STEM students from a single educational setting, which may limit the results' generalizability. Second, the study relied on self-reported questionnaire data, making the findings susceptible to response bias and subjective perceptions. Third, the study measured students' perceptions of mobile application adoption through perceived usefulness and perceived ease of use rather than actual usage behavior, and assessed self-regulated learning through self-reported practices rather than direct observation or academic performance measures. Furthermore, the study did not collect information on the duration

of mobile application use, exposure to specific applications, or whether app use was teacher-directed or voluntary. Fourth, the descriptive-correlational design allowed only for the examination of associations and did not permit causal inferences. Finally, although the instruments demonstrated satisfactory reliability and content validity, the study did not examine construct validity through Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA). Future studies should involve larger, more diverse samples, collect objective measures of technology use and learning outcomes, and employ more rigorous validation and research designs.

CONCLUSION

This study identified significant positive relationships between mobile application adoption and self-regulated learning among senior high school students enrolled in General Chemistry. Students who reported higher levels of perceived usefulness and perceived ease of use also tended to report higher levels of goal setting, self-monitoring, self-reflection, engagement, and self-efficacy. The findings indicate that these variables are statistically associated within the study population. However, because the study employed a descriptive-correlational design, the results should not be interpreted as evidence that mobile application adoption causes, influences, improves, or enhances self-regulated learning practices. The study offers several practical implications for Chemistry instruction. Given the observed associations between mobile application adoption and self-regulated learning dimensions, teachers may consider integrating mobile applications that incorporate progress tracking, reflective activities, goal-setting features, immediate feedback, and interactive learning resources. These recommendations are offered as practical considerations derived from the study findings and should not be interpreted as evidence of effectiveness. Curriculum planners may also integrate self-regulated learning strategies into mobile-supported instructional materials to encourage students to become more intentional and independent learners. The proposed Independent Learning Plan (ILP) may serve as a supplementary instructional framework for integrating self-regulated learning practices into General Chemistry instruction. However, the ILP should be regarded as a proposed output of the study rather than a validated intervention, as its effectiveness has not yet been empirically tested. Future research should examine these relationships using larger and more diverse samples from different schools and educational settings to

improve the generalizability of the findings. Researchers may also employ multiple regression analysis, structural equation modeling, or longitudinal research designs to investigate the predictive relationships among mobile application adoption and self-regulated learning dimensions. Furthermore, future studies should conduct pilot implementation, validation, and effectiveness testing of the proposed Independent Learning Plan to determine its applicability and potential value in enhancing self-regulated learning and academic outcomes in Chemistry education.

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