

Digital Learning Resource Acceptance and Utilization as Predictors of Chemistry Learning Engagement Among Grade 10 Students of Magsaysay National High School: Basis for a Proposed Intervention Program

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Publication history:

Received: August 21, 2026

Accepted: September 23, 2026

Revised: September 21, 2026

Published: September 24, 2026

International Journal of Sustainable and Integrated Studies, Vol. 1, No. 2, pp. 592–600, September 2026.

Abstract

This study examined digital learning resource acceptance and utilization as predictors of Chemistry learning engagement among Grade 10 students of Magsaysay National High School and provided a basis for the proposed CHEM-ENGAGE intervention program. Anchored in the Technology Acceptance Model, Task-Technology Fit Theory, and Student Engagement Framework, the study employed a quantitative, descriptive-correlational, and predictive design involving 136 Grade 10 students selected through proportionate stratified random sampling. Data were collected using a validated and pilot-tested 60-item researcher-made questionnaire and analyzed using descriptive statistics, Spearman's rank-order correlation, and standard multiple linear regression. Students demonstrated high digital learning resource acceptance ($M = 3.76$, $SD = 0.656$), while utilization ($M = 3.84$, $SD = 0.603$) and Chemistry learning engagement ($M = 3.86$, $SD = 0.653$) occurred often. Acceptance ($p = .608$, $p < .001$) and utilization ($p = .667$, $p < .001$) were significantly and positively related to engagement. The regression model was significant and explained 52.7% of the variance in engagement ($R^2 = .527$), with perceived ease of use ($\beta = .1917$, $p = .019$) and performance impact ($\beta = .2739$, $p = .005$) emerging as significant unique predictors. Challenges were evident in independent navigation, routine utilization, assessment preparation, active participation, enjoyment, feedback use, and problem-solving. The findings support implementing CHEM-ENGAGE to strengthen usability, purposeful and task-aligned utilization, visible learning benefits, and multidimensional engagement. The study supports SDG 4 (Quality Education) and is relevant to SDG 9 (Industry, Innovation and Infrastructure) through meaningful and accessible technology integration in secondary education. Its sustainability impact lies in promoting context-appropriate, manageable, and purposeful use of digital resources to support informed instructional and institutional decisions in Chemistry education.

Keywords: Chemistry Learning Engagement; Digital Learning Resources; Performance Impact; Perceived Ease of Use; Student Engagement; Task-Technology Fit; Technology Acceptance

1. Introduction

Digital learning resources such as instructional videos, online quizzes, simulations, virtual laboratories, websites, and digital modules provide students with additional ways to understand and interact with Chemistry concepts. These resources are particularly useful for visualizing abstract processes and supporting interactive learning, although their effectiveness depends on appropriate selection and instructional integration (Ali et al., 2023; Wohlfart et al., 2023). Access alone does not ensure meaningful use, as students may experience difficulties involving connectivity, devices, technical skills, and insufficient integration into instruction (Febaliza et al., 2025). Thus, understanding students' acceptance and utilization of digital resources is important in determining how technology relates to their engagement in Chemistry.

Digital learning resource acceptance reflects students' willingness to adopt technology for learning. Perceived usefulness and perceived ease of use remain important factors in educational technology acceptance (Davis, 1989; Granić, 2022; Rosli et al., 2022). Students are more likely to accept resources when these help clarify difficult concepts, support learning activities, and can be accessed and operated with minimal difficulty (Wu & Chen, 2017; Butt et al., 2021). Meaningful utilization also depends on whether technology matches the requirements of a learning task. Task-technology fit emphasizes the alignment between technological capabilities and task requirements (Goodhue & Thompson, 1995). In Chemistry, simulations may support visualization, virtual laboratories may facilitate experimentation, and online quizzes may provide immediate feedback. Research indicates that task-technology fit and actual technology use are associated with learning performance and engagement (Butt et al., 2021; Liu et al., 2023).

Student engagement consists of behavioral, emotional, and cognitive dimensions (Fredricks et al., 2004). Behavioral engagement involves participation, effort, and persistence; emotional engagement concerns interest, enjoyment, confidence, and other learning-related reactions; and cognitive engagement reflects the mental effort invested in understanding, analyzing, and applying knowledge. Digital resources can support these dimensions when they are interactive, relevant, accessible, and appropriately matched to learning tasks. Technology-task alignment has been associated with behavioral, emotional, and cognitive engagement (Liu et al., 2023). Philippine studies similarly indicate that digital and technology-supported approaches can promote participation, motivation, understanding, and engagement in science learning (Cano et al., 2022; De Guzman & Magpantay, 2022; Gaad, 2023; Cruz et al., 2024). However, technology does not automatically produce engagement, as outcomes remain influenced by instructional design, accessibility, and learning context (Bond et al., 2020; Schindler et al., 2017).

Digital learning has become increasingly important in Philippine basic education. However, connectivity problems, limited devices, differences in digital skills, and teacher preparation continue to influence students' experiences with technology (Bustillo & Aguilos, 2022; Briones et al., 2023; Colegado, 2025). Philippine education policies have also emphasized accessible and flexible learning resources and stronger technology integration (Department of Education, 2020a, 2020b; Department of Education, 2022). These conditions demonstrate that providing technology alone is insufficient. Digital resources must be accessible, useful, manageable, and appropriate for students' learning tasks to support meaningful engagement.

The study is anchored in the Technology Acceptance Model (Davis, 1989), Task-Technology Fit Theory (Goodhue & Thompson, 1995), and Student Engagement Framework (Fredricks et al., 2004). The Technology Acceptance Model explains students' acceptance through perceived usefulness and perceived ease of use, while Task-Technology Fit Theory explains how the alignment between technology and learning tasks can influence utilization and performance. The Student Engagement Framework explains students' behavioral, emotional, and cognitive involvement in learning. Accordingly, digital learning resource acceptance and utilization serve as the predictor variables, while Chemistry learning engagement serves as the outcome variable. Acceptance is examined through perceived usefulness and perceived ease of use; utilization through task characteristics, technology characteristics, task-technology fit, actual utilization, and performance impact; and engagement through behavioral, emotional, and cognitive dimensions.

Existing research generally supports positive relationships among technology acceptance, utilization, task-technology fit, engagement, and learning performance (Al-Rahmi et al., 2020; Butt et al., 2021; Liu et al., 2023). However, many studies have focused on university learners, general online environments, or science subjects other than junior high school Chemistry. Philippine studies have also commonly examined digital resources, access, or engagement separately rather than integrating acceptance, utilization, and multidimensional engagement. The present study therefore examines whether digital learning resource acceptance and utilization predict the Chemistry learning engagement of Grade 10 students at Magsaysay National High School. It seeks to identify the acceptance and utilization dimensions associated with behavioral, emotional, and cognitive engagement and provide a basis for an intervention program promoting more meaningful and effective use of digital learning resources.

The study primarily supports SDG 4 – Quality Education by examining how digital resources can contribute to meaningful and engaging Chemistry learning. It is also relevant to SDG 9 – Industry, Innovation and Infrastructure because effective digital education depends on accessible technologies and infrastructure. Challenges involving connectivity, devices, and digital access remain important considerations in Philippine education (Bustillo & Aguilos, 2022; Briones et al., 2023; Colegado, 2025).

The study contributes to educational and technological sustainability by emphasizing effective and context-appropriate use of digital resources rather than technology availability alone. Understanding students' acceptance, utilization, and engagement can help teachers and schools select resources that are useful, manageable, accessible, and appropriate for Chemistry learning tasks. The findings may also support more informed instructional and institutional decisions concerning sustainable technology integration in secondary science education.

2. Material and methods

2.1 Research Design

The study used a quantitative, descriptive-correlational, and predictive research design. The descriptive component assessed digital learning resource acceptance through perceived usefulness and perceived ease of use; utilization through task characteristics, technology characteristics, task-technology fit, actual utilization, and performance impact; and Chemistry learning engagement through behavioral, emotional, and cognitive dimensions. Correlational analysis determined the relationships between acceptance, utilization, and engagement, while predictive analysis identified which dimensions significantly predicted overall Chemistry learning engagement. As no variables were manipulated, findings were interpreted as relationships and predictive contributions rather than causal effects.

2.2 Locale of the Study

The study was conducted at Magsaysay National High School during School Year 2026–2027. The setting was selected because Grade 10 students encountered Chemistry concepts and used digital learning resources such as educational videos, websites, digital modules, online quizzes, mobile applications, interactive simulations, and virtual laboratories. The school context allowed the study to examine students' actual experiences with digital resources and provide evidence for developing an intervention responsive to their learning and engagement needs.

2.3 Respondents of the Study

The population consisted of 206 Grade 10 students from six sections: Galilei, Mendel, Einstein, Aristotle, Dalton, and Archimedes. Using Slovin's formula with a 5% margin of error, a sample of 136 students was determined. The respondents represented the different Grade 10 sections proportionately to preserve representation across the population.

2.4 Sample and Sampling Procedure

Proportionate stratified random sampling was employed, with each Grade 10 section serving as a stratum. Based on the proportional allocation, the 136 respondents consisted of 12 students from Galilei, 24 from Mendel, 25 from Einstein, 23 from Aristotle, and 26 each from Dalton and Archimedes. Within each section, eligible students were assigned numbers based on the official class list and randomly selected through a random-number generator or draw-lots procedure. Students who declined, failed to return the required consent, or were unavailable during data collection were replaced through random selection from the same section, maintaining proportional representation and equal selection opportunities.

2.5 Research Instrument

A researcher-made questionnaire was developed from the statement of the problem, conceptual and theoretical frameworks, related literature, and operational definitions of the variables. It consisted of 60 statements divided into three major parts and ten six-item subscales. Digital learning resource acceptance contained 12 items measuring perceived usefulness and perceived ease of use based on the Technology Acceptance Model of Davis (1989). Digital learning resource utilization contained 30 items measuring task characteristics, technology characteristics, task-technology fit, actual utilization, and performance impact based on the Task-Technology Fit perspective of Goodhue and Thompson (1995). Chemistry learning engagement contained 18 items assessing behavioral, emotional, and cognitive engagement following Fredricks, Blumenfeld, and Paris (2004). All items used a five-point scale. Mean scores of 4.21–5.00, 3.41–4.20, 2.61–3.40, 1.81–2.60, and 1.00–1.80 represented very high, high, moderate, low, and very low extent, respectively. For actual utilization, the corresponding frequency interpretations were always, often, sometimes, rarely, and never. Subscale and composite scores were calculated by averaging the relevant items or dimensions. The instrument underwent content validation by qualified validators with relevant expertise in science or Chemistry education, educational technology, research methodology, and assessment. It was subsequently pilot-tested among 35 students with characteristics similar to the target respondents but who were excluded from the main study. Cronbach's alpha coefficients for the ten dimensions ranged from .825 to .936, while the major scales ranged from .919 to .967. The complete 60-item questionnaire obtained an alpha of .976, indicating good to excellent internal consistency and supporting its use in the main data collection.

2.6 Data Gathering Procedure

Formal permission was secured from the school principal, followed by coordination with Grade 10 advisers and the Chemistry teacher. Participants were randomly selected according to the approved proportional allocation.

Because the respondents were minors, written parent or guardian consent and student assent were secured before participation. Before questionnaire administration, the researcher explained the study's purpose, voluntary nature, confidentiality safeguards, and instructions. Students completed the questionnaire independently, with clarification limited to general directions and terminology. Completed questionnaires were collected and checked for unanswered items without pressuring students to respond. Responses were coded using participant numbers rather than names, encoded in a password-protected file, checked for completeness and accuracy, and prepared for statistical analysis. Findings were subsequently used as the basis for developing the proposed intervention program.

2.7 Data Analysis Techniques

Descriptive and inferential statistics were used, with inferential tests evaluated at the .05 level of significance. Mean and standard deviation summarized the extent and variability of students' acceptance, utilization, and Chemistry learning engagement. Spearman's rank-order correlation was used to determine the direction and strength of the relationships between overall digital learning resource acceptance and Chemistry learning engagement and between overall utilization and engagement. This nonparametric procedure was selected because normality assessment indicated that the distributions did not fully satisfy the assumption required for Pearson correlation. Statistical significance was interpreted together with the magnitude and direction of the coefficients. Standard multiple linear regression determined which dimensions of acceptance and utilization significantly predicted overall Chemistry learning engagement. The seven predictors were perceived usefulness, perceived ease of use, task characteristics, technology characteristics, task-technology fit, actual utilization, and performance impact. The model was evaluated using the F test, R^2 , adjusted R^2 , regression coefficients, t values, p values, and confidence intervals. Before inferential analysis, the dataset was screened for missing values and encoding errors. Distributional characteristics, linearity, regression residual normality, homoscedasticity, independence of errors, multicollinearity, and influential observations were examined using the appropriate diagnostic procedures. Departures from normality supported the use of Spearman's rho for the correlational analyses. The proposed intervention program was subsequently developed from dimensions with comparatively lower mean scores and variables demonstrating meaningful relationships or significant predictive contributions to Chemistry learning engagement.

2.8 Ethical Considerations

The study protected participants' dignity, safety, privacy, and rights. School permission, parent or guardian consent, and student assent were obtained before participation. Participation was voluntary, and students could decline or withdraw without penalty or consequences for their grades or school standing. No student names were recorded on the questionnaire. Participant codes were used, individual responses were kept confidential, and only aggregated findings were reported. Printed records were securely stored, while electronic data were password-protected and accessible only to authorized research personnel. Data were retained only for the period required by the school or approving institution and were subsequently securely destroyed or permanently deleted. Results were reported accurately regardless of whether they supported the study hypotheses.

3. Results and Discussion

3.1 Digital Learning Resource Acceptance

3.1.1 Perceived Usefulness

Perceived usefulness was rated at a high extent ($M = 3.93$, $SD = 0.734$). All indicators received high ratings, with effective completion of Chemistry learning activities obtaining the highest mean ($M = 4.04$, $SD = 0.969$) and effectiveness in reviewing Chemistry concepts receiving the lowest ($M = 3.82$, $SD = 1.030$). Overall, students recognized digital resources as useful for understanding, visualization, task completion, review, work quality, and assessment preparation. The finding supports the Technology Acceptance Model of Davis (1989), which identifies perceived usefulness as a major factor in technology acceptance. It is also consistent with Wu and Chen (2017), Butt et al. (2021), Cardona-Acevedo et al. (2025), and Momani et al. (2023), who emphasized that learners value digital technologies when they improve understanding, efficiency, and task performance. In Chemistry, digital resources can be particularly useful for representing abstract and submicroscopic processes.

3.1.2 Perceived Ease of Use

Perceived ease of use was rated at a high extent ($M = 3.59$, $SD = 0.761$). Students rated their ability to find needed Chemistry information or activities highest ($M = 3.74$, $SD = 1.030$). However, navigating digital Chemistry resources without much assistance received the lowest rating ($M = 3.39$, $SD = 1.040$), interpreted as moderate. Overall acceptance remained high ($M = 3.76$, $SD = 0.656$), with perceived usefulness ($M = 3.93$) exceeding perceived ease of use ($M = 3.59$). The result supports the Technology Acceptance Model while showing that ease of use is affected by practical learning conditions. Rosli et al. (2022), Bustillo and Aguilos (2022), and Briones et al. (2023) identified access, experience, connectivity, device availability, and support as factors affecting technology use. Thus, students may recognize the value of digital resources while still requiring guidance in navigating Chemistry-specific platforms.

3.2 Digital Learning Resource Utilization

3.2.1 Task Characteristics

Task characteristics were rated at a high extent ($M = 3.97$, $SD = 0.689$). Understanding scientific concepts and processes received the highest mean ($M = 4.11$, $SD = 0.892$), while solving complex problems obtained the lowest ($M = 3.73$, $SD = 0.931$). Students generally recognized that Chemistry requires conceptual understanding, analysis, visualization, experimentation, problem-solving, and access to additional materials. These findings indicate that Chemistry involves diverse learning demands that may require different forms of digital support. The result is consistent with Goodhue and Thompson's (1995) Task-Technology Fit Theory, which emphasizes matching technological capabilities with task requirements. Simulations, virtual laboratories, quizzes, videos, and collaborative platforms may therefore serve different purposes depending on the Chemistry activity.

3.2.2 Technology Characteristics

Technology characteristics were rated at a high extent ($M = 3.79$, $SD = 0.722$). Accuracy of Chemistry information obtained the highest rating ($M = 3.87$, $SD = 0.949$), while responsiveness and proper functioning received the lowest ($M = 3.70$, $SD = 0.872$). Students generally perceived the available resources as accurate, accessible, interactive, clear, and reliable. The results emphasize the importance of technology quality in sustaining meaningful use. Butt et al. (2021) and Rosli et al. (2022) associated system and information quality with satisfaction, utilization, and performance. Colegado (2025) similarly emphasized that accessible and familiar technologies may be more practical than sophisticated resources requiring stronger connectivity or devices.

3.2.3 Task-Technology Fit

Task-technology fit was rated at a high extent ($M = 3.82$, $SD = 0.683$). The usefulness of simulations for understanding difficult Chemistry concepts received the highest rating ($M = 3.95$, $SD = 0.846$), whereas the appropriateness of digital resources for Chemistry activities received the lowest ($M = 3.71$, $SD = 0.958$). The findings suggest that students generally perceived digital technologies as suited to Chemistry tasks, although their appropriateness may vary according to the activity. This agrees with Liu et al. (2023), Butt et al. (2021), and Wu and Chen (2017), who emphasized that alignment between technological capabilities and learning demands contributes to engagement, continued utilization, and performance.

3.2.4 Actual Utilization

Actual utilization was rated as often ($M = 3.73$, $SD = 0.769$). Students most frequently used digital resources when additional explanations were needed ($M = 3.88$, $SD = 1.050$), while use for quiz and examination preparation received the lowest mean ($M = 3.58$, $SD = 1.130$). General frequent use was similarly lower ($M = 3.59$, $SD = 1.040$). The pattern indicates that students often used digital resources according to immediate learning needs rather than as a consistently embedded study practice. Meaningful utilization therefore requires structured integration into review, assignments, assessment preparation, and enrichment rather than relying solely on students to access resources when difficulties arise.

3.2.5 Performance Impact

Performance impact was rated at a high extent ($M = 3.88$, $SD = 0.774$). More efficient completion of Chemistry tasks received the highest rating ($M = 4.03$, $SD = 0.902$), while improved problem-solving ability received the lowest ($M = 3.77$, $SD = 1.040$). Overall utilization was rated as often ($M = 3.84$, $SD = 0.603$), with task characteristics obtaining the highest dimension mean ($M = 3.97$) and actual utilization the lowest ($M = 3.73$). The results indicate that students perceived digital resources as beneficial to efficiency, work quality, understanding, confidence, problem-solving, and application. However, deeper problem-solving and routine utilization could still be strengthened. The findings are consistent with Butt et al. (2021), Liu et al. (2023), Gaad (2022), and Cruz et al. (2024), who associated appropriately designed technology-supported learning with engagement and performance outcomes.

3.3 Chemistry Learning Engagement

3.3.1 Behavioral Engagement

Behavioral engagement was rated as often ($M = 3.82$, $SD = 0.733$). Responsible use of digital learning resources obtained the highest mean ($M = 3.98$, $SD = 1.000$), whereas active participation in digitally supported Chemistry activities received the lowest ($M = 3.64$, $SD = 1.110$). The results indicate that students were generally responsible and persistent when using digital resources, although active participation was comparatively weaker. This suggests the importance of moving beyond compliant technology use toward activities requiring active interaction and problem-solving. The finding agrees with Fredricks et al. (2004), Liu et al. (2023), and Gaad (2022), who emphasize participation, effort, persistence, and task completion as important behavioral indicators.

3.3.2 Emotional Engagement

Emotional engagement was rated as often ($M = 3.82$, $SD = 0.753$). Confidence in using digital resources and looking forward to digitally supported Chemistry lessons both obtained the highest mean ($M = 3.88$), while enjoyment received the lowest ($M = 3.73$, $SD = 0.946$). The findings indicate generally positive emotional

involvement, although confidence and perceived value did not necessarily produce equally strong enjoyment. This is consistent with Fredricks et al. (2004), who conceptualized emotional engagement through students' interest and affective responses. De Guzman and Magpantay (2022) and Cruz et al. (2024) likewise showed that interactive and structured digital approaches can support interest and motivation.

3.3.3 Cognitive Engagement

Cognitive engagement was rated as often ($M = 3.93$, $SD = 0.740$), making it the highest engagement dimension. Carefully studying information presented through digital Chemistry resources received the highest mean ($M = 4.10$, $SD = 0.921$), while using digital feedback to improve understanding received the lowest ($M = 3.85$, $SD = 1.010$). Overall Chemistry learning engagement was rated as often ($M = 3.86$, $SD = 0.653$), with behavioral and emotional engagement both obtaining $M = 3.82$. The findings indicate that students demonstrated substantial mental involvement in digital Chemistry learning, although feedback use could be further strengthened. Liu et al. (2023), Gaad (2022), and Cano et al. (2022) similarly emphasized that interactive and appropriately matched resources can support analysis, explanation, and conceptual understanding rather than passive exposure.

3.4 Relationships Between Digital Learning Resources and Chemistry Engagement

3.4.1 Acceptance and Chemistry Learning Engagement

Digital learning resource acceptance had a statistically significant positive relationship with Chemistry learning engagement, $\rho = .608$, $df = 134$, $p < .001$. The relationship was strong, indicating that higher acceptance scores tended to occur with higher engagement scores. The null hypothesis of no significant relationship was therefore rejected. The finding indicates an association rather than causation. Students who perceived digital resources as useful and manageable also tended to report stronger behavioral, emotional, and cognitive engagement. This is consistent with Davis's (1989) Technology Acceptance Model and the findings of Wu and Chen (2017), Granić (2022), and Rosli et al. (2022). It also complements Bond et al. (2020) and Schindler et al. (2017), who found that educational technology can support engagement depending on the technology and context.

3.4.2 Utilization and Chemistry Learning Engagement

Digital learning resource utilization was significantly and positively related to Chemistry learning engagement, $\rho = .667$, $df = 134$, $p < .001$. The strong relationship indicates that students reporting more favorable and purposeful utilization also tended to demonstrate higher engagement. The corresponding null hypothesis was rejected. The result suggests that engagement is associated not only with favorable perceptions of technology but also with how resources are actually used and aligned with learning tasks. The finding is consistent with Goodhue and Thompson's (1995) Task-Technology Fit Theory and Liu et al. (2023), Butt et al. (2021), and Al-Rahmi et al. (2020). It also supports local findings from Gaad (2022), Cruz et al. (2024), and Colegado (2025), which showed that purposeful and context-sensitive technology integration can support participation and learning.

3.5 Predictors of Chemistry Learning Engagement

The multiple regression model was statistically significant, $F(7, 128) = 20.414$, $p < .001$, with $R = .726$ and $R^2 = .527$. The seven predictors collectively explained 52.7% of the variance in Chemistry learning engagement, with an adjusted R^2 of .501. Perceived ease of use significantly predicted engagement ($B = 0.1644$, $SE = 0.0689$, $\beta = .1917$, $t = 2.386$, $p = .019$, 95% CI [0.0281, 0.301]), while performance impact was also a significant positive predictor ($B = 0.2309$, $SE = 0.0810$, $\beta = .2739$, $t = 2.852$, $p = .005$, 95% CI [0.0707, 0.391]). Perceived usefulness ($p = .338$), task characteristics ($p = .051$), technology characteristics ($p = .468$), task-technology fit ($p = .119$), and actual utilization ($p = .290$) did not make statistically significant unique contributions when the other predictors were controlled. The findings demonstrate that although overall acceptance and utilization were strongly associated with engagement, only perceived ease of use and performance impact contributed significant unique predictive information in the simultaneous model. This distinction may reflect shared variance among the related predictors. The findings support the Technology Acceptance Model by emphasizing manageable technology and Task-Technology Fit reasoning by highlighting students' experienced performance benefits. Digital resources therefore appear particularly relevant to engagement when students can operate them with manageable effort and perceive clear learning benefits.

3.6 Proposed Digital Chemistry Learning Intervention

Based on the findings, the proposed CHEM-ENGAGE: Easy, Purposeful, and Performance-Oriented Digital Chemistry Learning program prioritizes perceived ease of use and performance impact because these emerged as significant unique predictors of engagement. It also addresses comparatively weaker indicators involving independent navigation, regular utilization, assessment preparation, active participation, enjoyment, feedback use, and problem-solving. The intervention includes digital Chemistry orientation and navigation support, a curated mobile-friendly Chemistry resource hub, task-resource matching, guided simulation and virtual-laboratory activities, regular digital review, structured feedback-to-learning activities, engagement monitoring, and access and technical support. Implementation may be adjusted according to available devices, connectivity, teacher workload, and curriculum schedules. Evaluation may compare relevant validated subscale scores before and after

implementation and monitor access, task completion, reflection quality, feedback use, and consistency of digital review. Claims regarding intervention effectiveness would require an appropriate approved evaluation design.

4. Conclusion & Recommendations

The study concluded that Grade 10 students generally demonstrated high acceptance and frequent utilization of digital learning resources and were often engaged in learning Chemistry, with cognitive engagement being the strongest engagement dimension. Both digital learning resource acceptance and utilization were significantly and positively associated with Chemistry learning engagement. The regression model further showed that perceived ease of use and performance impact were the significant unique predictors of engagement, indicating that students tended to be more engaged when digital resources were manageable to use and provided recognizable learning benefits. Overall, the findings emphasize the importance of usable, purposeful, task-aligned, and performance-oriented digital resources rather than simply increasing the availability of technology.

Magsaysay National High School should implement the proposed CHEM-ENGAGE program, emphasizing ease of use, visible learning benefits, regular and purposeful utilization, active participation, assessment preparation, productive use of feedback, and appropriate alignment between digital resources and Chemistry tasks. Students should receive guidance in navigating and using appropriate resources, while teachers should integrate accessible, reliable, mobile-friendly, and task-appropriate digital activities into instruction. The school should support these efforts through curated Chemistry resources, technical and access assistance, teacher development, and monitoring of behavioral, emotional, and cognitive engagement. Future studies should examine other schools and populations, include additional learner and contextual variables, incorporate objective or qualitative evidence, and use longitudinal or experimental approaches to evaluate changes and the effectiveness of the proposed intervention.

The findings are limited to 136 Grade 10 students from Magsaysay National High School during School Year 2026–2027 and should not be automatically generalized to other schools, grade levels, subjects, or populations. The study employed a quantitative, nonexperimental, descriptive-correlational and predictive design based primarily on self-reported survey data; therefore, the observed relationships and predictive contributions cannot establish causality. The model explained 52.7% of the variance in Chemistry learning engagement, leaving 47.3% potentially associated with variables outside the study. Factors such as prior achievement, motivation, teacher practices, internet connectivity, device access, family support, and other learner or contextual conditions were outside the scope of the investigation and were not tested.

5. Compliance with ethical standards

The authors declare no conflict of interest. This study received no external funding, and the authors acknowledge Magsaysay National High School and the Grade 10 students who participated in the study. Participation was voluntary, informed consent from parents or guardians and student assent were obtained, and data were collected through non-invasive survey methods while maintaining confidentiality and ensuring that no identifying information was disclosed.

REFERENCES

- Abaton, G. R., & Malabarbas, L. T. (2021). Contextualized learning resource in Grade 9 science: Its effect on students' critical-thinking skills. *Jurnal Pendidikan IPA Indonesia*, 10(4), 534–543. <https://doi.org/10.15294/jpii.v10i4.31348>
- Alhashem, F., & Alfaiakawi, A. (2023). Technology-enhanced learning through virtual laboratories in chemistry education. *Contemporary Educational Technology*, 15(4), Article ep474. <https://doi.org/10.30935/cedtech/13739>
- Ali, S. B., Talib, C. A., & Jamal, A. M. (2023). Digital technology approach in chemistry education: A systematic literature review. *Journal of Natural Science and Integration*, 6(1). <https://doi.org/10.24014/jnsi.v6i1.21777>
- Al-Rahmi, A. M., Shamsuddin, A., & Alismael, O. A. (2020). Task-technology fit model: The factors affecting students' academic performance in higher education. *Universal Journal of Educational Research*, 8(12), 6831–6843. <https://doi.org/10.13189/ujer.2020.081249>
- Avelino, Z. L. (2025). Learning the concept of genes, DNA, and chromosome through a developed virtual laboratory website. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 11(1), 399–405. <https://doi.org/10.22219/jpbi.v11i1.39774>
- Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International*

- Briones, M. R., Prudente, M., & Errabo, D. D. (2023). Characteristics of Filipino online learners: A survey of science education students' engagement, self-regulation, and self-efficacy. *Education Sciences*, 13(11), Article 1131. <https://doi.org/10.3390/educsci13111131>
- Bustillo, E., & Aguilos, M. (2022). The challenges of modular learning in the wake of COVID-19: A digital divide in the Philippine countryside revealed. *Education Sciences*, 12(7), Article 449. <https://doi.org/10.3390/educsci12070449>
- Butt, S., Mahmood, A., Saleem, S., Rashid, T., & Ikram, A. (2021). Students' performance in online learning environment: The role of task-technology fit and actual usage of system during COVID-19. *Frontiers in Psychology*, 12, Article 759227. <https://doi.org/10.3389/fpsyg.2021.759227>
- Cahapay, M. B., & Anoba, J. L. D. (2021). Technological pedagogical knowledge self-efficacy and continuance intention of Philippine teachers in remote education amid COVID-19 crisis. *Journal of Pedagogical Research*, 5(3), 68–79. <https://doi.org/10.33902/JPR.2021370614>
- Cano, J. S. (2022). Development and validation of simulation-based instructional materials on central dogma of molecular biology for senior high school. *International Journal of Technology in Education and Science*, 6(2), 373–387. <https://doi.org/10.46328/ijtes.368>
- Cano, J. S., Olvis, P. R., Disca, B. Y., & Docena, A. F. (2022). Simulation-based instructional materials on central dogma of molecular biology: Basis in studying genetics for Grade 12 learners. *International Journal of Technology in Education*, 5(2), 249–268. <https://doi.org/10.46328/ijte.219>
- Cardona-Acevedo, S., Agudelo-Ceballos, E., Cumpa Vásquez, J. T., Martínez Rojas, E., Valencia-Arias, A., Jimenez Garcia, J. A., & Benjumea-Arias, M. L. (2025). E-learning technologies at the secondary education level: Literature review. *Frontiers in Education*, 10, Article 1539763. <https://doi.org/10.3389/feduc.2025.1539763>
- Castro, R. (2025). The effects of chemistry virtual laboratories on the academic achievement of secondary-level learners: A meta-analysis. *Integrated Science Education Journal*, 6(1), 24–37. <https://doi.org/10.37251/isej.v6i1.1379>
- Colegado, J. C. (2025). Digital innovations in science education in the Philippines: A scoping review of teaching practices and tools. *International Journal of Research and Innovation in Social Science*, 9(3S), 6549–6556. <https://doi.org/10.47772/IJRISS.2025.903SEDU0479>
- Crudo, A. D., de Lara, A. B., Hababag, F. G., Lacaba, A. A. A., & Mariano, J. M. P. (2023). Level of engagement of junior high school students in science during online distance learning. *International Journal of Humanities and Social Sciences*, 15(1), 19–41. <https://doi.org/10.26803/ijhss.15.1.2>
- Cruz, J. A. D., Calixtro, L. A., Batinga, J. J. C., Balila, A. M. D., Mamuad, H. A. P., & Antonio, J. M. A. (2024). Enhancing student engagement and motivation in science using the Flip-J strategy. *Universal Journal of Educational Research*, 3(2), 142–154. <https://doi.org/10.17613/dwhc-tg79>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- de Guzman, F. I., & Magpantay, M. S. (2022). Students' engagement and meaningful learning experiences in using digitized concept stories in Grade 7 biology. *LUKAD: An Online Journal of Pedagogy*, 2(1), 31–53. <https://lukad.org/wp-content/uploads/2022/08/31-53-De-Guzman--Magpantay.pdf>
- Department of Education. (2020a). *Adoption of the Basic Education Learning Continuity Plan for School Year 2020–2021 in light of the COVID-19 public health emergency* (DepEd Order No. 012, s. 2020). https://www.deped.gov.ph/wp-content/uploads/2020/06/DO_s2020_012.pdf
- Department of Education. (2020b). *Policy guidelines for the provision of learning resources in the implementation of the Basic Education Learning Continuity Plan* (DepEd Order No. 018, s. 2020). https://www.deped.gov.ph/wp-content/uploads/2020/08/DO_s2020_018.pdf
- Department of Education. (2022). *Adoption of the Basic Education Development Plan 2030* (DepEd Order No. 024, s. 2022). https://www.deped.gov.ph/wp-content/uploads/2022/05/DO_s2022_024.pdf
- Department of Education. (2023a). *Adoption of the National Learning Recovery Program in the Department of Education* (DepEd Order No. 013, s. 2023). https://www.deped.gov.ph/wp-content/uploads/DO_s2023_013.pdf
- Department of Education. (2023b). *Development of session guides and conduct of training activities on the integration of emerging technologies in teaching and learning* (DM-CT-2023-309).
- Department of Education. (2023c). *Revised guidelines on the implementation of the Department of Education Computerization Program* (DepEd Order No. 016, s. 2023). https://www.deped.gov.ph/wp-content/uploads/DO_s2023_016.pdf
- Febaliza, A., Kadarohman, A., Aisyah, S., & Abdullah, N. (2025). Digital technology in chemistry education: Investigating students' engagement with chemistry software. In H. S. Panigoro et al. (Eds.), *Proceedings of the 2nd International Conference on Sciences, Mathematics, and Education 2023 (ICOSMED 2023)* (pp. 644–653). Atlantis Press. https://doi.org/10.2991/978-2-38476-410-5_53
- Fortuno, D. E., & Ricafort, J. D. (2020). The effect of the flipped classroom model on students' performance in Grade 10 chemistry. *International Journal of Engineering Science and Computing*.

- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109. <https://doi.org/10.3102/00346543074001059>
- Gaad, A. L. V. (2022). The effects of online collaborative learning on student achievement and engagement. *IAFOR Journal of Education*, 10(3), 31–49. <https://doi.org/10.22492/ije.10.3.02>
- Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly*, 19(2), 213–236. <https://doi.org/10.2307/249689>
- Granić, A. (2022). Educational technology adoption: A systematic review. *Education and Information Technologies*, 27(7), 9725–9744. <https://doi.org/10.1007/s10639-022-10951-7>
- Liu, K., Yao, J., Tao, D., Yang, T., Wang, J., & Lu, S. (2023). Influence of individual-technology-task-environment fit on university student online learning performance: The mediating role of behavioral, emotional, and cognitive engagement. *Education and Information Technologies*, 29, 11773–11799. <https://doi.org/10.1007/s10639-023-11833-2>
- Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction*, 60, 225–236. <https://doi.org/10.1016/j.learninstruc.2017.12.007>
- Momani, M. A. K. A., Alharahasheh, K. A., & Alqudah, M. (2023). Digital learning in sciences education: A literature review. *Cogent Education*, 10(2), Article 2277007. <https://doi.org/10.1080/2331186X.2023.2277007>
- Paje, Y. M., Rogayan, D. V., Jr., & Dantic, M. J. P. (2021). Teachers' utilization of computer-based technology in science instruction. *International Journal of Technology in Education and Science*, 5(3), 427–446. <https://doi.org/10.46328/ijtes.261>
- Rosli, M. S., Saleh, N. S., Md. Ali, A., Abu Bakar, S., & Mohd Tahir, L. (2022). A systematic review of the technology acceptance model for the sustainability of higher education during the COVID-19 pandemic and identified research gaps. *Sustainability*, 14(18), Article 11389. <https://doi.org/10.3390/su141811389>
- Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2017). Computer-based technology and student engagement: A critical review of the literature. *International Journal of Educational Technology in Higher Education*, 14, Article 25. <https://doi.org/10.1186/s41239-017-0063-0>
- Wohlfart, O., Wagner, A. L., & Wagner, I. (2023). Digital tools in secondary chemistry education: Added value or modern gimmicks? *Frontiers in Education*, 8, Article 1197296. <https://doi.org/10.3389/feduc.2023.1197296>
- Wu, B., & Chen, X. (2017). Continuance intention to use MOOCs: Integrating the technology acceptance model and task-technology fit model. *Computers in Human Behavior*, 67, 221–232. <https://doi.org/10.1016/j.chb.2016.10.028>