ENHANCING CHEMISTRY EDUCATION IN THE DIGITAL ERA: THE ROLE OF SELF-EFFICACY IN ADDRESSING STUDENTS' MISCONCEPTIONS ON ACID–BASE CONCEPT

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Abstract. This study examines the relationship between self-efficacy and misconceptions in acid–base chemistry among seventh-grade students (n=121) in digital learning contexts. A correlational mixed- methods design used validated self-efficacy questionnaires (α=0.89) and four-tier diagnostic tests (reliability=0.87). Results showed that although 45% of students reported high self-efficacy, misconceptions remained substantial (32.8%), especially in identifying acid-base solutions (42.36%), indicator behavior (53.72%), and pH interpretation (46.28%). A moderate positive correlation emerged between self-efficacy and misconceptions (r=0.52, p<0.01), strongest among middle achievers (r=0.61). Notably, 42.1% of high-self-efficacy students held multiple misconceptions, indicating a confidence– misconception paradox associated with passive digital content use. Interview data revealed that highly confident students often relied on superficial online explanations, while lower-confidence students showed greater metacognitive awareness. Self-efficacy dimensions explained 31.4% of misconception variance (R^2=0.314, p<0.001). Findings suggest that self-efficacy in digital learning requires calibration, supported by targeted misconception-based instruction, refutational approaches, digital literacy, and metacognitive scaffolding.

Keywords: Self-Efficacy, Misconceptions, Acid-Base, Digital Learning, Four-Tier Diagnostic Test.

INTRODUCTION

Understanding the concept of acids and bases is fundamental in chemistry learning, serving as the foundation for various topics such as equilibrium, chemical reactions, buffer solutions, and analytical chemistry. Despite its importance, research consistently shows that students at various educational levels struggle with persistent misconceptions in this area, including misinterpreting pH values and the logarithmic nature of the pH scale, confusing strong versus weak acids and bases with concentration, misunderstanding indicator behavior and specificity, and incorrectly generalizing acid-base reactions and neutralization processes (Salame, Montero, & Eschweiler, 2022; Permatasari, Suyono, & Yuanita, 2024). These misconceptions represent alternative conceptual frameworks constructed from prior experiences, everyday language, and intuitive reasoning, which can be deeply rooted and resistant to change even after formal instruction (Kahveci, 2023; Tümay, 2023). Such alternative conceptions hinder deeper conceptual understanding and negatively affect students' problem-solving abilities in both academic and real-world contexts, with studies showing that misconception rates can exceed 40% in specific acid-base topics among secondary students (Cooper, Underwood, & Hilley, 2020; Aydin & Tortumlu, 2020). In the contemporary digital era, the landscape of chemistry education has been fundamentally transformed by the ubiquity of digital technologies and online learning resources. From a social humanities perspective, digital technologies are not merely neutral tools for content delivery but rather active mediators that shape how students interact with chemical concepts, construct knowledge, develop psychological dispositions toward learning, and participate in communities of practice (Pahriah et al., 2025). Students today have unprecedented access to diverse educational resources from YouTube tutorials and interactive simulations to online forums and virtual laboratories that can either support or complicate their conceptual understanding depending on the quality, accuracy, and pedagogical design of these resources (Coppola, Daniels, & Pontrello, 2021). This digital transformation raises critical questions about how affective and motivational factors such as self-efficacy interact with students' consumption of digital learning materials and their susceptibility to or resilience against misconceptions.

At the same time, self-efficacy, defined as students' belief in their ability to succeed in specific academic tasks, has been identified as a critical factor influencing learning outcomes in chemistry (Ferrell, Phillips, & Barbera, 2021; Kaya, Borgerding, & Ferdous, 2025). Self-efficacy shapes not only motivation and goal-setting but also persistence in overcoming learning difficulties and the use of effective learning strategies (Schunk & DiBenedetto, 2021). Students with low self- efficacy may experience anxiety when confronted with complex concepts, avoid seeking help, and rely on rote memorization, thereby reinforcing misconceptions and preventing conceptual change (Villafañe et al., 2020). Conversely, students with high self-efficacy are theoretically expected to demonstrate greater resilience in cognitive conflict, actively seek clarification, employ sophisticated problem-solving strategies, and successfully restructure their understanding when faced with contradictory evidence (Usher et al., 2019). However, recent research suggests a more complex relationship where high self-efficacy does not always correspond to accurate conceptual understanding and may, in some cases, reinforce misconceptions when students are confidently incorrect, a phenomenon potentially exacerbated in digital learning environments where students may develop superficial confidence from consuming professionally produced but scientifically questionable content (Ferrell et al., 2021; Fung, Southam, & Hyde, 2022).

From a humanistic perspective, addressing misconceptions in chemistry education cannot be separated from supporting students' psychological well-being, confidence, and sense of agency in their learning processes. The social humanities approach to digital-era education recognizes that students are not merely cognitive processors of information but whole persons whose emotional states, beliefs about themselves, social interactions, and digital literacy competencies all contribute to their learning trajectories (Chan & Bauer, 2020; Brandriet & Bretz, 2020). In this context, examining the relationship between student self-efficacy and acid-base misconceptions is essential for advancing chemistry education that is both cognitively rigorous and humanistically responsive. This study is rationalized by the need to bridge cognitive and affective domains, as addressing misconceptions cannot be separated from supporting students' confidence and belief in their learning capabilities, yet confidence must be appropriately calibrated to actual understanding, a calibration that becomes even more complex in digital learning environments where students encounter vast amounts of information of varying quality and must develop critical literacy skills to navigate these resources effectively (Adesope et al., 2021).

The benefits of this research are substantial and directly relevant to the conference theme of Social Humanities in the Digital Era. First, it provides empirical evidence to guide teachers in designing instructional strategies that simultaneously target misconceptions and appropriately calibrate self-efficacy in digital learning contexts, avoiding both the pitfalls of low confidence that prevents engagement and overconfidence that prevents recognition of conceptual errors or critical evaluation of digital information sources (Pahriah et al., 2025; Dou et al., 2021). Second, it informs the development of assessment tools that consider both conceptual understanding and confidence levels in digital environments, such as multi-tier diagnostic tests that can identify students who are confidently wrong due to uncritical consumption of digital content and require different interventions than those who are tentatively correct but lack confidence to engage with digital resources (Kaltakci-Gurel, Eryilmaz, & McDermott, 2020). Third, findings contribute to theoretical frameworks explaining how affective variables mediate cognitive change in digital-era science education, particularly the conditions under which self-efficacy facilitates versus hinders conceptual change when students are immersed in information-rich digital environments (Sinatra, Heddy, & Lombardi, 2021).

The objectives of this study are threefold: first, to identify common misconceptions students hold about acids and bases in digital learning contexts, including pH interpretation, acid- base strength versus concentration, indicator behavior, and neutralization reactions, with particular attention to high-prevalence misconceptions exceeding 45% and how digital resources may contribute to these misconceptions; second, to measure student self-efficacy in learning chemistry across three dimensions including cognitive self-efficacy, practical self-efficacy, and problem- solving self-efficacy, particularly as applied to acid-base contexts and digital learning environments; and third, to analyze the relationship between self-efficacy and misconception persistence in the digital era, exploring whether higher self-efficacy associates with fewer misconceptions as theoretically expected or paradoxically correlates with greater misconception prevalence when confidence is misaligned with understanding and derived from superficial engagement with digital content.

Previous research has examined misconceptions in acid-base chemistry (Djarwo & Kafiar, 2023; Permatasari et al., 2024) or self-efficacy in chemistry learning (Ferrell et al., 2021; Kaya et al., 2025) largely in isolation from one another, and few studies have explicitly examined these constructs within the context of digital learning environments. By explicitly exploring the relationship between self-efficacy and misconceptions in digital learning contexts, this study contributes to a more holistic and nuanced understanding of chemistry learning in the digital era that acknowledges the complex interplay between what students know, what they believe about their capabilities, how their confidence reflects their understanding, how they interact with digital learning resources, and how these factors shape their learning trajectories and openness to conceptual change (Sinatra et al., 2021; Chan & Bauer, 2020).

RESEARCH METHOD

This study employed a correlational research design with mixed methods to examine the relationship between student self-efficacy and acid-base misconceptions within digital learning contexts. The research involved 121 seventh-grade students, consisting of 58 males and 63 females, from a public school in Bogor, Indonesia, during the 2024/2025 academic year. Participants were selected using purposive sampling based on their enrollment in chemistry and completion of acid- base instruction. All participants had regular access to digital devices including smartphones, tablets, or computers and internet connectivity for educational purposes. Data were collected using a digital self-efficacy questionnaire, a four-tier diagnostic test administered online, supplementary questions about digital learning behaviors, and follow-up interviews conducted via video conferencing, all conducted over three weeks under standardized conditions.

The self-efficacy instrument consisted of 15 items on a 7-point Likert scale adapted from validated chemistry self-efficacy scales (Dou et al., 2020; Ferrell et al., 2021) and administered through Google Forms. The instrument measured three dimensions: cognitive self-efficacy for understanding concepts with 5 items, practical self-efficacy for laboratory skills with 5 items, and problem-solving self-efficacy for applying knowledge with 5 items. Items were contextualized to include digital learning scenarios, such as statements about confidence in understanding acid-base concepts when learning from online videos and ability to solve acid-base problems using digital simulation tools effectively. Total scores ranged from 15 to 105, with Cronbach's alpha of 0.89 indicating excellent internal consistency. Students were categorized as having low self-efficacy for scores between 15 and 50, moderate self-efficacy for scores between 51 and 80, or high self-efficacy for scores between 81 and 105 based on score distribution.

The misconception diagnostic test was a four-tier instrument with 13 items covering three subtopics: characteristics of acids and bases with 4 items, identification of acid-base solutions with 5 items, and determination of acidity and alkalinity scales with 4 items. The test was administered through an online platform that recorded response times and allowed real-time monitoring of student progress. The four-tier structure included a first tier with multiple-choice content questions, a second tier with confidence rating ranging from 1 representing guessing to 4 representing very sure, a third tier with reasoning selection, and a fourth tier with confidence in reasoning. Following the framework developed by Gurel and colleagues in 2015, responses were categorized as Scientific Knowledge when students provided correct answer and reasoning with high confidence, False Positive when correct answer was given but with incorrect reasoning, False Negative when incorrect answer was provided despite correct reasoning, Misconception when both incorrect answer and reasoning were given with high confidence, and Lack of Knowledge when low confidence responses were recorded. The instrument showed reliability coefficients of 0.720 for the first tier and 0.705 for the third tier. Following Caleon and Subramaniam (2010), misconceptions were considered significant at prevalence rates of 10% or higher, with items showing misconception prevalence greater than 45% identified for detailed analysis.

To understand students' digital learning behaviors, a supplementary questionnaire assessed five key areas: frequency and duration of using digital resources for chemistry learning including YouTube videos, educational websites, simulations, and online forums; types of digital content consumed such as teacher-created videos, commercial educational channels, peer-generated content, and interactive simulations; strategies for evaluating the credibility and accuracy of online chemistry information; perceived influence of digital resources on their confidence and understanding of acid- base concepts; and experiences with misconceptions encountered in digital learning materials. This questionnaire was administered digitally alongside the self-efficacy survey and provided quantitative data on digital engagement patterns that could be correlated with self-efficacy levels and misconception prevalence.

A semi-structured interview protocol with 10 open-ended questions explored students' reasoning patterns, sources of misconceptions, the role of self-efficacy in learning, and their experiences with digital learning resources. Specific questions addressed how students select and evaluate online chemistry content, instances where digital resources either clarified or confused their understanding, whether their confidence in acid-base concepts was influenced by the professional appearance or popularity of digital content regardless of accuracy, and their awareness of potential misinformation in online educational materials. Twenty students were purposively selected representing four categories: high self-efficacy with high misconceptions, high self-efficacy with low misconceptions, low self-efficacy with high misconceptions, and low self-efficacy with low misconceptions with 5 students in each category. Interviews lasted between 15 and 25 minutes, were conducted via video conferencing platforms such as Zoom and Google Meet with screen-sharing capabilities to review specific test items and digital resources, were conducted in Bahasa Indonesia, audio-recorded with consent, and transcribed verbatim for analysis. Data collection occurred in three stages within the digital learning ecosystem. Week 1 involved administration of the self-efficacy questionnaire and digital learning behavior survey through Google Forms, with automated data collection and preliminary analysis. Week 2 involved the online diagnostic test administered through a secure educational platform with features for real- time monitoring, automatic scoring of tiers 1 and 3, and data export for analysis. Week 3 involved individual interviews conducted via video conferencing with selected students, allowing for rich qualitative exploration of their reasoning and digital learning experiences. Students were assured that participation would not affect grades and were instructed to respond honestly, particularly regarding confidence levels and their actual practices in using digital learning resources. Ethical approval was obtained from the institutional review board, and parental consent was secured for all participants given their minor status.

Quantitative analysis included descriptive statistics such as frequencies, percentages, means, and standard deviations for understanding categories across items and subtopics, as well as for digital learning behavior variables. Misconception prevalence was calculated for each item and visualized by subtopic using color coding. Inferential analyses using SPSS version 26.0 included Spearman's rho correlation after normality testing using Shapiro-Wilk test to examine relationships between self-efficacy and misconception prevalence, as well as between digital learning behaviors and both self-efficacy and misconceptions, at significance level of 0.05. Multiple linear regression was conducted to determine predictive power of self-efficacy dimensions and digital learning engagement patterns on misconceptions while controlling for gender and achievement level. Assumptions including linearity, homoscedasticity, multicollinearity, and independence of residuals were verified before analysis. Additional analyses explored whether the self-efficacy-misconception relationship differed based on patterns of digital content consumption including passive viewing versus active engagement, frequency of use, and types of resources accessed.

Qualitative analysis followed the thematic analysis approach developed by Braun and Clarke in 2006, with two researchers independently coding 30% of transcripts resulting in Cohen's kappa of 0.84 indicating strong inter-rater reliability. Themes focused on common misconceptions, reasoning differences by self-efficacy level, the role of confidence in conceptual change, and critically the influence of digital learning resources on students' understanding and self-efficacy. Specific attention was paid to how students described their interactions with digital content distinguishing between passive consumption and critical engagement, instances where digital resources reinforced misconceptions despite professional presentation, and differences in digital literacy practices between students with calibrated versus miscalibrated self-efficacy. Qualitative and quantitative findings were integrated through triangulation to explain mechanisms linking self-efficacy, misconceptions, and digital learning behaviors, providing a comprehensive understanding of how students navigate chemistry learning in the digital era.

RESULT AND ANALYSIS

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1.1 Students' Self-Efficacy Levels

The distribution of students' self-efficacy levels is presented in Table 1. Nearly half of the students at 45% reported high self-efficacy, while 38% were at the moderate level, and 17% at the low level. This distribution suggests that most seventh-grade students possess reasonable confidence in their chemistry learning abilities, though a notable minority still experiences low self-efficacy that may hinder their engagement with challenging concepts (Kaya et al., 2025; Rosenzweig & Wigfield, 2023).

Table 1. Distribution of Students' Self-Efficacy Levels

Self-Efficacy Level	Percentage (%)
High (>5.5)	45
Moderate (3.5-5.5)	38
Low (<3.5)	17

When examined by domain, students showed the highest confidence in practical self- efficacy related to laboratory procedures with mean of 5.8 and standard deviation of 0.9, followed by cognitive self-efficacy for general chemistry concepts with mean of 5.4 and standard deviation of 1.1. In contrast, problem-solving self-efficacy specifically for acid-base concepts was notably lower with mean of 4.6 and standard deviation of 1.3, with only 65% of students reporting confidence in this area. This suggests that acid-base chemistry remains a major challenge despite students' general confidence in chemistry (Villafañe et al., 2020; Fung et al., 2022). These findings are consistent with research highlighting that abstract chemical ideas and multi-representational thinking required in acid-base chemistry often lower students' self-efficacy compared to more observable, hands-on learning experiences (Ferrell et al., 2021).

1.2 Students' Self-Efficacy in Digital Learning Contexts

Analysis of self-efficacy specifically within digital learning contexts revealed important patterns. When items were analyzed separately for digital-specific scenarios, students demonstrated moderate confidence with mean of 5.2 and standard deviation of 1.2 in learning acid-base concepts through digital resources, which was lower than their general chemistry self-efficacy but higher than their problem-solving self-efficacy. This suggests a relatively positive disposition toward digital learning tools, though not accompanied by commensurate critical evaluation skills as discussed later.

Cross-tabulation of self-efficacy levels with self-reported digital learning behaviors showed that 72% of high self-efficacy students reported frequently using YouTube videos and educational websites for chemistry learning for more than 3 hours per week, compared to 58% of moderate self-efficacy and 35% of low self-efficacy students with chi-square value of 18.4 and p- value less than

0.001. However, when asked about strategies for evaluating the credibility of online chemistry content, only 28% of high self-efficacy students reported systematic evaluation practices such as checking credentials, cross-referencing multiple sources, and consulting teachers, compared to 31% of moderate self-efficacy and surprisingly 42% of low self-efficacy students. This counterintuitive pattern suggests that students with high self-efficacy may be more susceptible to accepting online information uncritically due to overconfidence, while students with low self- efficacy demonstrate greater caution and critical awareness when engaging with digital resources, a finding with significant implications for digital literacy instruction in chemistry education.

1.3 Misconception Patterns

The overall distribution of understanding categories across all 13 items revealed concerning patterns. Only 28.4% of responses demonstrated scientific knowledge, while misconceptions accounted for 36.8% of responses, false positives represented 15.2%, false negatives 10.5%, and lack of knowledge 9.1%. These results indicate that misconceptions were more prevalent than correct understanding, highlighting significant conceptual difficulties in acid-base chemistry among seventh-grade students (Kahveci, 2023; Tümay, 2023).

When analyzed by subtopic, misconceptions were particularly high in identification of acid-base solutions at 42.36%, followed by determination of acidity and alkalinity scales at 31.41%, and characteristics of acids and bases at 25.34%. The identification subtopic's high misconception rate suggests students struggle most with applying acid-base concepts to recognize substances and interpret indicators in practical contexts (Cooper et al., 2020; Permatasari et al., 2024).

Detailed analysis identified four items with misconception prevalence exceeding 45%: item Q5 at 47.1%, item Q8 at 48.8%, item Q10 at 45.5%, and item Q12 at 52.1%. These items represented critical misconceptions documented in Table 2. In item Q12, regarding indicator color changes, 52.1% of students believed that all indicators show the same color in the same solution regardless of pH range, demonstrating fundamental misunderstanding of indicator specificity (Salame et al., 2022).

Table 2. Specific High-Prevalence Misconceptions in Acid-Base Topics

Item	Sub-Topic	Misconception Type	Percentage (%)
Q4	Characteristics of Acid and Base	Strength vs. concentration confusion	35.9
Q5	Identification of Acid and Base Solution	Overgeneralization of acid properties	47.1
Q7		Color change mechanism	38.4
Q12		Universal indicator behavior	52.1
Q8	Determination scale on Acidity and Alkalinity	Inverse pH-acidity relationship	48.8
Q9		Neutral point misunderstanding	33.7
Q10		Linear concentration-pH relationship	45.5

For item Q8, concerning the pH scale, 48.8% held an incorrect inverse relationship misconception, believing that higher pH always means weaker acid rather than understanding the logarithmic relationship between pH and hydrogen ion concentration. Item Q5 showed 47.1% misconception regarding the identification of acidic substances in daily life, with students overgeneralizing that all sour-tasting substances are strong acids. Finally, item Q10 revealed 45.5% misconception about the relationship between concentration and pH, with students believing that doubling concentration would double the pH value (Aydin & Tortumlu, 2020).

Additional significant misconceptions exceeding 30% included confusion between acid strength and concentration at 35.9%, misunderstanding of color change mechanisms at 38.4%, and incorrect identification of the neutral point on pH scales at 33.7%. These findings echo earlier research showing that students often transfer everyday experiences and intuitive reasoning to scientific contexts, which can strengthen but also distort their understanding (Cooper et al., 2020; Muntholib et al., 2020).

1.4 Digital Learning Behaviors and Misconception Pattern

Analysis of digital learning behaviors revealed critical insights into how students' interactions with online resources related to their misconceptions. Among the 121 participants, 89% reported using YouTube as their primary digital resource for chemistry learning, 67% used educational websites including Khan Academy and educational blogs, 54% used interactive simulations such as PhET and virtual labs, and 31% participated in online forums or study groups. However, the quality and accuracy of engagement varied considerably.

Students with high misconception rates defined as 5 or more misconceptions demonstrated significantly different digital consumption patterns compared to those with low misconception rates defined as 2 or fewer misconceptions. High-misconception students reported greater reliance on a single source without cross-verification at 78% versus 34% with chi-square value of 24.7 and p-value less than 0.001, preference for entertaining fast-paced videos over comprehensive explanatory content at 71% versus 41% with chi-square value of 11.8 and p-value less than 0.001, passive viewing without pausing to reflect or take notes at 83% versus 47% with chi-square value of 17.3 and p-value less than 0.001, and limited awareness of content creator credentials at 85% versus 52% with chi-square value of 15.1 and p-value less than 0.001.

Qualitative analysis of specific digital content consumed revealed that many popular YouTube videos perpetuated the exact misconceptions identified in the diagnostic test. For example, several videos with high view counts exceeding 100,000 incorrectly explained pH as a measure of acid strength rather than hydrogen ion concentration, reinforcing the item Q8 misconception. Other popular content oversimplified indicator behavior, suggesting all indicators work the same way corresponding to item Q12 misconception, or presented linear concentration-pH relationships through misleading visualizations corresponding to item Q10 misconception. The professional production quality, engaging presentation style, and high view counts of these videos appeared to lend them unwarranted authority, particularly among students with high self-efficacy who felt confident in their ability to learn from these sources without critical evaluation.

In contrast, low-misconception students demonstrated more strategic and critical digital learning practices including deliberately seeking multiple sources to compare explanations, pausing videos to work through examples independently, using digital simulations to test predictions and explore what-if scenarios, consulting teacher-recommended resources, and discussing confusing content with peers or teachers before accepting it as accurate. These practices align with principles of critical digital literacy and active learning in technology-enhanced environments (Coppola et al., 2021).

1.5. Correlation Between Self-Efficacy and Misconceptions

The relationship between students' self-efficacy and misconceptions revealed a significant moderate positive correlation with r value of 0.52 and p-value less than 0.01, indicating that higher self-efficacy was associated with greater misconception prevalence. This counterintuitive finding challenges the assumption that confidence always supports accurate learning and suggests that self-efficacy may paradoxically reinforce incorrect understanding when students are confidently wrong, particularly in digital learning environments where confidence may be derived from consumption of professionally presented but scientifically inaccurate content (Ferrell et al., 2021; Chan & Bauer, 2020).

Analysis by self-efficacy dimensions showed that problem-solving self-efficacy demonstrated the strongest positive correlation with misconceptions at r value of 0.58 and p-value less than 0.01, followed by cognitive self-efficacy at r value of 0.51 and p-value less than 0.01, while practical self-efficacy showed the weakest but still significant correlation at r value of 0.43 and p- value less than 0.01. This pattern suggests that students who feel most confident in their ability to solve acid-base problems are also most likely to hold persistent misconceptions, possibly because their confidence, often bolstered by successfully answering questions on platforms that may not adequately test deep conceptual understanding, prevents them from questioning their understanding or seeking clarification (Villafañe et al., 2020).

When examined by achievement level based on overall diagnostic test performance, the correlation remained consistently positive across all groups, as presented in Table 3. Interestingly, middle achievers in the 50th to 75th percentile showed the strongest relationship with r value of 0.61 and p-value less than 0.01, suggesting that moderate performers are most vulnerable to confidence-accuracy mismatches. High achievers above the 75th percentile showed a moderate correlation with r value of 0.45 and p-value less than 0.01, while low achievers below the 50th percentile demonstrated r value of 0.49 and p-value less than 0.01 (Fung et al., 2022).

Table 3. Correlation of Self-Efficacy and Misconceptions by Student Achievement Level

Subgroup	Correlation (r)	Significance
High Achievers	0.45	$p < 0.01$
Middle Achievers	0.58	$p < 0.01$
Low Achievers	0.49	$p < 0.01$

When digital learning behavior variables were introduced into the analysis, additional patterns emerged. Students categorized as passive digital consumers characterized by high frequency of video watching, low engagement with interactive elements, and no cross-verification showed stronger positive correlations between self-efficacy and misconceptions at r value of 0.67 and p-value less than 0.001 compared to active digital learners at r value of 0.31 and p-value less than 0.05. This suggests that the self-efficacy-misconception paradox is significantly mediated by the quality of students' engagement with digital resources, not merely their access to or frequency of using these resources.

Multiple regression analysis revealed that self-efficacy dimensions and digital learning behaviors collectively explained 31.4% of variance in misconception prevalence with R-squared value of 0.314, F statistic of 13.27 with degrees of freedom 4 and 116, and p-value less than 0.001. Problem-solving self-efficacy emerged as the strongest predictor with beta coefficient of 0.38 and p-value less than 0.001, followed by cognitive self-efficacy with beta coefficient of 0.26 and p-value less than 0.01, and passive digital consumption patterns with beta coefficient of 0.22 and p-value less than 0.01, while practical self-efficacy was not a significant predictor in the model.

1.6. Qualitative Insights into the Self-Efficacy-Misconception Paradox

Interview data provided deeper understanding of how high self-efficacy can paradoxically coexist with misconceptions in digital learning contexts. Students with high self-efficacy and high misconceptions typically exhibited overconfidence in their learning strategies and demonstrated limited metacognitive awareness. One student stated that after watching three or four YouTube videos on pH, they felt completely confident they understood it and did not think they needed to check other sources or ask questions. Another high self-efficacy student explained their preference for videos with simple explanations and colorful animations, which made complex concepts seem easier than they actually were, and admitted they never questioned whether the information was scientifically accurate as long as it made sense at a surface level.

In contrast, students with low self-efficacy paradoxically demonstrated greater critical awareness and recognition of knowledge gaps. One low self-efficacy student explained that because they did not feel confident, they always tried to find multiple sources to confirm information and often asked teachers if what they learned online was correct. Another stated that when watching chemistry videos, they would pause frequently to make sure they really understood and would replay sections multiple times, a practice that actually promoted deeper engagement despite lower initial confidence.

Students with high self-efficacy and low misconceptions represented the ideal profile characterized by both confidence and critical engagement. These students reported using digital resources strategically, cross-referencing information, testing their understanding through practice problems and simulations, and actively seeking feedback. They described approaching online content with healthy skepticism, evaluating explanations based on alignment with course materials and scientific principles rather than merely presentation quality. One such student explained their strategy of watching multiple videos on the same topic to see if different teachers explained it consistently, and if they found contradictions, they would research further or ask their teacher to clarify.

CONCLUSION

This study reveals a complex and paradoxical relationship between self-efficacy and misconceptions in acid-base chemistry within digital learning environments. While nearly half of the seventh-grade students demonstrated high self-efficacy, misconceptions were prevalent at 32.8% overall, with particularly concerning rates in identification of acid-base solutions at 42.36%. Most significantly, the moderate positive correlation between self-efficacy and misconceptions with r value of 0.52 challenges traditional assumptions that confidence universally supports accurate learning. The finding that 42.1% of students exhibited high self-efficacy while simultaneously holding multiple misconceptions reveals a confidence-misconception paradox that is intensified by superficial digital content consumption patterns.

The research demonstrates that the relationship between self-efficacy and conceptual understanding is mediated significantly by the quality of students' engagement with digital resources rather than merely their access to or frequency of using these resources. Students categorized as passive digital consumers, who engaged in high-frequency video watching with low interactive engagement and no cross-verification, showed stronger positive correlations between self-efficacy and misconceptions compared to active digital learners. This suggests that the digital learning environment creates new challenges for chemistry education, where professionally produced but scientifically questionable content can paradoxically build student confidence while reinforcing misconceptions.

From a social humanities perspective, these findings underscore the need for integrated humanistic-technological pedagogical approaches that recognize students as whole persons navigating an increasingly complex digital educational landscape. Chemistry education in the digital era must address not only cognitive dimensions of conceptual understanding but also affective dimensions of appropriately calibrated self-efficacy and critical dimensions of digital literacy. Effective instruction must combine confidence-building with misconception diagnosis, refutational teaching strategies, critical evaluation of digital information sources, and metacognitive training that helps students develop awareness of their own understanding and learning processes.

Practical implications for teachers include the necessity of implementing diagnostic assessments that identify both misconceptions and confidence levels simultaneously, designing interventions differentiated based on self-efficacy-misconception profiles rather than assuming all high-confidence students are performing well, explicitly teaching critical digital literacy skills including evaluation of online chemistry content for accuracy and credibility, incorporating metacognitive prompts and reflection activities that encourage students to question their understanding and confidence, and fostering classroom cultures where uncertainty and questioning are valued rather than perceived as signs of weakness.

Future research should investigate longitudinal development of the self-efficacy- misconception relationship across different chemistry topics and educational levels, effectiveness of specific interventions designed to calibrate self-efficacy with accurate understanding in digital contexts, comparative analysis of different digital learning platforms and their impact on both self- efficacy and conceptual understanding, and exploration of cultural factors that may influence how students in different contexts develop confidence and interact with digital learning resources.

This research contributes to the growing body of knowledge at the intersection of cognitive science, affective psychology, and digital education, demonstrating that effective chemistry education in the twenty-first century requires attention to the complex interplay between what students know, what they believe about their capabilities, and how they navigate the vast and variable landscape of digital learning resources. By illuminating the confidence-misconception paradox and its relationship to digital learning behaviors, this study provides a foundation for developing more comprehensive and humanistically responsive approaches to chemistry education that support both accurate conceptual understanding and appropriately calibrated self-efficacy in the digital era.

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