Mastery Gaps in Acid-Base: A Need Assessment of Grade 12 Senior High School Students

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ABSTRACT

Acid–base chemistry is a foundational topic in senior high school curricula, underpinning advanced concepts in chemical reactions, equilibria, and analytical applications. Despite its importance, learners frequently exhibit difficulties in understanding and applying acid–base principles, particularly in computational and conceptual contexts. This study aimed to assess the level of mastery of Grade 12 students in acids and bases and to identify the least mastered competencies through a comprehensive needs assessment. Data were collected from fifty (50) purposively selected students at Kapatagan National High School using a 30-item validated multiple-choice diagnostic test aligned with the Department of Education's Most Essential Learning Competencies (MELCs). Descriptive quantitative analyses, including mean scores, standard deviations, and mastery level interpretations, were employed to evaluate performance. Results indicated that the overall performance of learners was low, with 92% failing to meet expectations and only 8% achieving a fairly satisfactory level. Learners demonstrated Low Mastery in fundamental definitions of Arrhenius, Brønsted–Lowry, and Lewis acids and bases (MPS = 77.5), while application- and computation-based competencies, including buffer systems, Henderson–Hasselbalch calculations, and salt hydrolysis, were identified as least mastered (MPS = 51.0–57.4). These findings reveal substantial gaps in conceptual understanding and quantitative application, highlighting the need for targeted instructional interventions, guided problem-solving, and enhanced conceptual discussions. The study provides empirical evidence to inform curriculum development and pedagogical strategies aimed at improving mastery in acid–base chemistry.

Keywords: acid–base, conceptual understanding, chemistry education, least mastered competencies, senior high school

INTRODUCTION

Chemistry is frequently perceived by learners as a challenging and disengaging subject due to its abstract theoretical constructs, quantitative problem-solving demands, and requirement for advanced cognitive processing and conceptual integration. Among the various domains of chemistry, acids and bases consistently emerge as one of the most conceptually demanding topics for students. This content area is central to chemistry education, serving as a foundational framework for understanding a broad range of chemical reactions and phenomena in both natural and industrial contexts. However, empirical studies indicate that classroom instruction on acids and bases often lacks meaningful interactivity, with many students exhibiting reluctance to articulate their reasoning, engage in discourse, or pose questions during instruction. Consequently, chemistry lessons frequently become teacher-centered and cognitively passive, diminishing student engagement and conceptual development (Khaira & Ibrahim, 2024).

Acid–base chemistry occupies a pivotal position in senior high school curricula, as it underpins more advanced topics such as chemical equilibrium, reaction kinetics, and analytical techniques including titrimetric analysis. Despite its instructional importance, research in chemistry education consistently demonstrates that students struggle to construct a coherent and scientifically accurate understanding of acid–base concepts. Learners commonly encounter difficulties in explaining key ideas such as pH, neutralization, acid and base strength, and the theoretical models that describe acid–base behavior. Notably, these conceptual challenges often persist even after formal instruction, indicating limitations in conventional pedagogical approaches (Sheppard, 2006).

Persistent misconceptions in acid–base chemistry—such as the conflation of strength with concentration, erroneous interpretations of neutralization processes, and inappropriate application of acid–base theories—have been documented across diverse educational contexts and learner populations. These misconceptions are frequently attributed to students' reliance on everyday language, intuitive reasoning, and rote memorization, all of which are insufficient for the development of robust conceptual frameworks grounded in chemical principles (Schmidt-McCormack et al., 2019).

Furthermore, research suggests that naïve conceptions formed during early stages of chemistry learning may persist into later educational levels and even adulthood if they are not explicitly elicited and addressed. Consistent with this assertion, national assessment data and classroom-based diagnostic reports (DepEd Learning Competency Analysis, 2023) reveal persistent underperformance in competencies related to: (a) identifying the properties and definitions of acids and bases; (b) explaining neutralization reactions and salt formation; (c) solving pH and pOH calculations; and (d) relating acid–base strength to the degree of ionization. These findings align with international research identifying acid–base chemistry as one of the least understood areas within the discipline.

Such learning difficulties can result in substantial gaps in students' chemistry competencies, particularly in topics that require the integration of theoretical models with quantitative reasoning. Identifying the specific areas in which these learning gaps occur, as well as the competencies that are least mastered, is therefore essential for the design of targeted instructional interventions. In this context, the present study aims to determine the level of mastery of learning competencies in acids and bases through a comprehensive needs assessment of Grade 12 senior high school students' conceptual understanding. The findings of this study are intended to provide educators and future researchers with an empirical, data-driven foundation for the development of instructional strategies and interventions that promote meaningful learning and sustained achievement in chemistry.

METHODOLOGY

This study employed a descriptive research design utilizing a quantitative approach to examine students' conceptual understanding of acid–base chemistry. The primary objective was to identify learning gaps by analyzing the least mastered competencies among Grade 12 senior high school students. A descriptive design was deemed appropriate, as it facilitates the systematic collection, analysis, and interpretation of numerical data to characterize existing learning conditions and performance patterns without manipulating instructional variables.

Development of the Assessment Instrument. Prior to administration to the main respondents, the assessment instrument underwent a rigorous validation process consisting of content validation and pilot testing. The initial instrument comprised fifty (50) multiple-choice items designed to assess students' conceptual understanding of acid–base competencies aligned with the Department of Education's senior high school chemistry curriculum.

Content validation was conducted by a panel of five experts, including three senior high school chemistry teachers and two university lecturers specializing in chemistry education. The validators evaluated each item in terms of relevance, clarity, curricular alignment, and appropriateness of difficulty. Based on the experts' feedback, ambiguous, redundant, and misaligned items were revised or eliminated to ensure comprehensive coverage of essential acid–base competencies.

The revised 50-item diagnostic test was subsequently administered to a pilot group of 150 Grade 12 STEM students who were not included in the main study. Pilot test data were subjected to item analysis, including the computation of difficulty indices, discrimination indices, and the reliability coefficient using Cronbach's alpha. Items that were excessively easy, overly difficult, or demonstrated poor discriminatory power were removed. This process resulted in a refined 30-item instrument.

The finalized 30-item test was administered to the main sample of fifty (50) students. The instrument demonstrated acceptable validity and reliability and was deemed suitable for identifying students' learning gaps and determining the least mastered competencies in acid–base chemistry.

Data Analysis. The collected data were systematically tabulated, analyzed, and interpreted using appropriate descriptive statistical techniques. The results are presented in the succeeding tables, which provide an accurate and organized representation of learners' performance across assessed competencies. These findings served as the basis for determining mastery levels and identifying specific areas of conceptual difficulty among the respondents.

Table 1. Descriptors for Students' Performance on Diagnostic Test

Index	Description	PERCENTAGE	REMARKS
27-30	Outstanding	90 – 100	Passed
24-26	Very Satisfactory	80 – 89	Passed
19-23	Satisfactory	80 – 84	Passed
15-19	Fairly Satisfactory	75 – 79	Passed
0-14	Did Not Meet Expectation	Below 75	Failed

Reference: DepEd Order No. 8 s, 2015

Table 2. Level of Students' Performance on Diagnostic Test

Mean Percentage Score (MPS)	Descriptive Equivalent
96 – 100%	Mastered
86 – 95%	Closely Approximating Mastery
66 – 85%	Moving Towards Mastery
36-65%	Average
13-34%	Low
5-14%	Very Low
0-4%	Absolutely No Mastery

Reference: DepEd PPST – Module 11

RESULTS AND DISCUSSION

Table 3. Summary of Assessment Results

Index	Frequency	Percentage	Interpretation	Remark
27-30	0	0%	Outstanding	Passed
26	0	0%	Very Satisfactory	Passed
24 – 25	0	0%	Satisfactory	Passed

23	4	8%	Fairly Satisfactory	Passed
0 – 22	46	92%	Did Not Meet Expectation	Failed
Total	50	100%		
Mean	**Standard Deviation**		**Interpretation**	**Remarks**
11.96	3.29		Did Not Meet Expectation	**Failed**

Table 3 presents a summary of the assessment results of the fifty (50) Grade 12 Senior High School students from Kapatagan National High School, Kapatagan, Lanao del Norte. The results indicate that none of the respondents attained performance classifications corresponding to the Outstanding (27–30), Very Satisfactory (26–27), or Satisfactory (24–25) levels. Only four (4) students, representing 8% of the cohort, achieved a score of 23, which falls under the Fairly Satisfactory category and is interpreted as Passed. In contrast, the vast majority of learners—forty-six (46) out of fifty, or 92%—obtained scores ranging from 0 to 22, classified as Did Not Meet Expectations and interpreted as Failed.

Overall, the distribution of scores reflects a markedly low level of academic performance, with a pronounced concentration in the failing range. These findings point to substantial learning deficiencies among the students and underscore the urgent need for targeted instructional intervention, structured remediation, and focused review of the least mastered competencies assessed in the study.

Mastery Levels of Grade 12 Students in Acids and Bases

Table 4. Mastery Level of Grade 12 Students on Acids and Base

Most Essential Learning Competency	**MPS**	**Descriptive Equivalent**
Define Arrhenius, Bronsted –Lowrey, and Lewis acids and bases	77.5	Low Mastery
Discuss the acid-base property	66.3	
Describe how buffer solution maintains it pH	51.0	Least Mastered
Calculate the pH of a buffer solution using the Henderson-Hasselbalch equation	57.4	
Explain how hydrolysis of salts affects the acidity or basicity of a solution	53.2	Least Mastered

Table 4 presents the mastery levels of Grade 12 students on selected essential learning competencies in acids and bases, as measured by their Mean Percentage Score (MPS) and corresponding descriptive equivalents. The results indicate that learners exhibited Low Mastery in foundational definitions of Arrhenius, Brønsted–Lowry, and Lewis acids and bases, with an MPS of 77.5, suggesting a partial grasp of core concepts. Mastery declined markedly for more conceptually demanding topics. The competency Discuss the acid–base property achieved an MPS of 66.3, reflecting a level approaching least mastery and indicating difficulties in explaining and applying acid–base characteristics.

The lowest levels of mastery were observed in competencies requiring analytical and computational skills. Specifically, describing the mechanism by which buffer solutions maintain pH recorded an MPS of 51.0, while calculating the pH of buffer solutions using the Henderson–Hasselbalch equation yielded an MPS of 57.4. Additionally, explaining how salt hydrolysis influences the acidity or basicity of a solution achieved an MPS of

53.2. These competencies were classified as least mastered, highlighting substantial challenges in integrating conceptual understanding with quantitative application.

Overall, the data suggest that learners perform relatively better in basic definitional knowledge but struggle considerably with application- and computation-based competencies, particularly those related to buffers and hydrolysis. These results underscore the need for targeted instructional strategies, including guided problem-solving, conceptual discussions, and remediation focused on the least mastered competencies, to enhance learners' overall mastery of acids and bases.

CONCLUSION

The study revealed that the overall performance of the Grade 12 cohort was low, with a mean score of 11.96 and a standard deviation of 3.29, indicating that most learners performed below satisfactory levels and that scores were concentrated near the mean. Based on the summary of assessment results, 92% of learners did not meet expectations, while only 8% attained a Fairly Satisfactory level. No learners reached the Satisfactory, Very Satisfactory, or Outstanding performance classifications.

Analysis of mastery per competency showed that learners demonstrated Low Mastery in fundamental definitions, including Arrhenius, Brønsted–Lowry, and Lewis acids and bases (MPS = 77.5). Performance declined in competencies requiring deeper conceptual reasoning and analytical application. The competencies describing how buffer solutions maintain pH (MPS = 51.0), calculating the pH of buffer solutions using the Henderson–Hasselbalch equation (MPS = 57.4), and explaining the effect of salt hydrolysis on solution acidity or basicity (MPS = 53.2) were identified as the least mastered. These findings indicate that students face pronounced difficulties in application- and computation-oriented tasks compared to fundamental definitions, revealing critical learning gaps in acids and bases.

RECOMMENDATION

Based on the findings, the following recommendations are proposed:

1. Targeted Remediation: Implement structured remedial instruction focusing on the least mastered competencies, particularly buffer systems, Henderson–Hasselbalch calculations, and salt hydrolysis.

2. Guided Problem-Solving: Incorporate step-by-step problem-solving exercises that bridge conceptual understanding with quantitative applications.

3. Conceptual Discussions: Facilitate interactive and collaborative learning activities to deepen understanding of acid–base principles beyond rote memorization.

4. Formative Assessment: Employ frequent low-stakes assessments, such as quizzes and diagnostic exercises, to monitor progress and inform instructional adjustments.

5. Future Research: Conduct longitudinal or experimental studies to evaluate the effectiveness of instructional interventions in improving mastery of acid–base competencies.

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