Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 7, 37-46
2026
Publisher: Learning Gate
DOI: 10.55214/2576-8484.v10i7.13197

Impact of text-based flipped instruction on grade 12 students' academic achievement in acid–base concepts

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Abstract: This study assessed academic achievement of Grade 12 students in acid-base concepts at Ada Senior High Technical School in Ghana. The study was framed by Social Constructivism theory proposed by Lev Vygotsky. To achieve the aim, quantitative method was used together with a quasi-experimental, pre-test/post-test design. A sample of 21 third-year Agricultural Science students were selected through the cluster sampling technique. A Likert-scale questionnaire was used to collect the data. Descriptive and inferential statistics were employed to analyze the data collected. The results show that students' posttest scores ($M = 15.81$, $SD = 2.32$) compared to pretest scores ($M = 10.33$, $SD = 3.97$), $t(20) = -6.87$, $p < 0.001$ were significance improvement in the teaching approach with a large effect size (Cohen's $d = 3.66$). Additionally, the results on the academic achievement of the students ($M = 4.59$, $p < 0.001$) show the flipped learning model has a positive effect on the students' learning outcomes. This affirms that flipped learning approach improved their conceptual understanding, promoted engagement, and increased learning responsibility. It was recommended the Ghana Education Service should employ flipped learning approach into chemistry curriculum frameworks to improve teaching and learning of abstract topics like acid-base concepts.

Keywords: *Acid–base concepts, Chemistry education, Constructivist learning, Low-resource schools, Student achievement, Text-based flipped learning. These findings highlight that flipped classrooms foster.*

1. Introduction

Policymakers are concerned about students' achievement in science concepts. This concern stems from the recognition that science education is a key driver in promoting national development and enhancing global competitiveness. Consequently, Science, Technology, Engineering, and Mathematics (STEM) education is being prioritized by governments in both developed and developing countries. Initiatives such as curriculum reforms, improved laboratory facilities, and targeted teacher training programs are being implemented within the Ghanaian education system [2], along with various scholarship schemes aimed at strengthening and supporting the STEM competencies of senior high school students [3, 4]. However, the traditional lecture-centered teaching approach remains dominant, limiting student participation and hindering effective understanding of scientific topics like acid-base concepts [5, 6].

Text-based flipped learning approach addresses challenges by promoting active student involvement in pre-class learning activities. This instructional approach permits students to engage with written learning materials independently before classroom sessions. Consequently, classroom time is allocated to collaborative problem-solving, conceptual application, and teacher-facilitated discourse [7]. In chemistry and related science disciplines, text-based flipped instruction has been demonstrated to improve students' conceptual understanding and critical thinking skills. Additionally, it enhances retention of abstract content, making it a promising alternative to traditional teaching methods [8].

History: Received: 9 April 2026; Revised: 12 June 2026; Accepted: 17 June 2026; Published: 6 July 2026
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Due to the role of text-based flipped instruction in improving students' conceptual understanding, this study was conducted at Ada Senior High Technical School in Ghana to examine the extent to which this approach has improved students' academic performance. It focused on the effect of text-based flipped instruction on Grade 12 students' achievement in acid–base concepts. Students at Ada Senior High Technical School face ongoing difficulties in understanding acid-base chemistry despite its essential importance in academic and practical settings [9]. Students' poor performance in this subject area could be attributed to traditional lecture-based teaching methods. The traditional method focused mainly on memorization instead of conceptual learning [10]. The research examined how this instructional strategy influences students' academic performance, engagement, and comprehension. The findings of this study provide evidence to support the use of innovative teaching methods in STEM education. They demonstrate that approaches like text-based flipped instruction can enhance student learning and improve instructional quality in Ghanaian senior high schools.

2. Literature Review

Effectiveness of flipped classroom teaching methods combined with conceptual change texts enhances student comprehension of acid-base concepts in high school chemistry [11]. The combination of flipped classroom models with guided inquiry or contextual learning methods results in significant improvements in student learning outcomes and scientific literacy skills [12-14]. Students grasp better concepts through conceptual change texts. The implementation of guided discovery learning-based modules proved effective in developing students' critical thinking abilities and learning results [15]. These innovative educational approaches offer potential solutions to overcome traditional teaching difficulties in acid-base concepts in high school chemistry.

Science relies on chemistry as its fundamental base to advance knowledge in medicine, industry, and environmental science, but secondary education students face difficulties in learning it due to its perceived complexity [9]. Students encounter substantial cognitive obstacles when learning chemistry because its abstract nature and extensive theoretical approach make understanding difficult unless teachers implement innovative educational methods [16]. Acid-base concepts are fundamental because they enable students to understand chemical reactions, pH control, and buffer systems, which are essential for advanced scientific studies [17]. Traditional lecture-based instruction mainly focuses on memorization instead of conceptual learning, resulting in student disengagement and ongoing knowledge deficits [18].

Research indicates that students view chemistry as challenging because it contains abstract concepts, demanding problem-solving tasks, and extensive theoretical requirements [19]. Students face challenges in chemistry as a result of failed teaching methods with insufficient practical experience. Also, the curriculum focuses on rote memorization instead of conceptual learning [20]. Student performance in chemistry depends heavily on their attitudes toward the subject, as unfavorable perceptions lead students to disengage and perform poorly [21]. Research indicates that innovative student-centered educational methods, including flipped learning and active learning strategies, offer potential solutions to enhance student engagement and understanding [22]. The success of new educational approaches for chemistry depends on proper implementation and access, especially in areas with limited resources [23].

Educational institutions across the board face problems with insufficient instructional materials and outdated curricula, with traditional lecture-based teaching methods that do not effectively engage students [22]. Research in Ghana shows that students experience particular difficulty with acid-base concepts, which leads to their poor performance in chemistry examinations, Essiam et al. [9]. Essiam et al. [9] highlight that student face additional challenges due to their large class sizes, insufficient laboratory facilities, and inadequate teacher training. Research and education recommend guided discovery learning, along with interactive instructional methods, as solutions to enhance student understanding and engagement Rusmansyah et al. [14]. Sablić and Mirosavljević [24] explain that the adoption of these methods faces resistance because educational infrastructure and teacher preparedness

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 7: 37-46, 2026
DOI: 10.55214/2576-8484.v10i7.13197

are limited, despite their demonstrated effectiveness in improving learning outcomes. Ada Senior High Technical School students experience ongoing challenges when learning acid-base concepts, resulting in poor academic results. The teacher-centered educational approaches that dominate the classroom create minimal student participation and understanding of concepts, which prevents learners from developing their chemistry problem-solving abilities [25]. Research indicates that students experience difficulties with acid-base material because the concepts remain abstract [13]. Additionally, interactive learning activities are scarce, leading to poor memory retention and limited practical application. The insufficient laboratory equipment creates further difficulties because students receive only theoretical lessons without practical laboratory work [26]. The combination of large class sizes and excessive teacher responsibilities limits personalized educational support, making it difficult for students to understand basic chemistry concepts [27]. The current educational challenges demand immediate implementation of alternative teaching methods focused on active learning and conceptual understanding [28].

Research shows that students who follow instructional materials before class through flipped learning demonstrate better academic results and increased motivation [25]. The text-based implementation makes this method suitable for places with limited digital resources and internet access [13]. The flipped classroom approach enables students to develop active participation while improving their memory retention and scientific problem-solving skills, as Muir [26] highlighted. Finkenberg and Trefzger [27] add that students who learn through flipped classrooms show enhanced self-regulated learning abilities and improved confidence when addressing complex chemistry material. This article investigates how text-based flipped learning affects students' achievement in acid-base concepts at Ada Senior Technical School.

Traditional teaching methods neglect different student learning preferences, resulting in student withdrawal from class and weak retention of essential concepts [29]. The abstract nature of chemistry becomes more difficult to retain when students do not participate actively and lack practical experience, which allows misconceptions to persist. It is therefore crucial to fill this knowledge gap through an investigation of text-based flipped learning as an accessible instructional approach for schools, particularly Ada Senior High Technical School students. Thus, there is a need to evaluate the effectiveness of the text-based flipped learning approach to improve student engagement, conceptual understanding, and overall performance in acid-based chemistry while eliminating video requirements.

3. Theoretical Framework

This research was informed by Social Constructivism, a theory developed by Vygotsky [1]. The theory proposes that learning occurs within a social context where learners construct knowledge through interaction, communication, and collaboration with others [1, 30]. From this view, students construct their knowledge through active engagement rather than passively receiving information, while personal experiences and cognitive engagement play essential roles. According to Rogoff [30] and Jerome et al. [31], social constructivism promotes collaborative interaction, which helps learners achieve deeper conceptual understanding and develop critical thinking through discussion and idea sharing. Collaborative interactions, misconceptions, and co-constructing knowledge enable students to develop a stronger understanding of complex scientific concepts like acid-base concepts.

The instructional strategy and methodological approach adopted in this study were informed by social constructivism, which assessed the effect of text-based flipped learning on Grade 12 students' achievement in acid–base concepts. The flipped learning approach enables learners to learn at their own pace before class, preparing them to be active and contribute during class periods. Promotion of collaborative learning, discussion, and problem-solving skills, which are in alignment with social interaction, is structured in classroom sessions as well as social constructivism. A quasi-experimental research design was used to determine the effectiveness of the teaching approach and to compare the results of learners who were taught using the instructional approach with those exposed to conventional methods. As the research design was guided by the principles of social constructivism, the study sought to enhance student interaction, peer collaboration, and guided classroom engagement. This would lead

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ISSN: 2576-8484
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to the improvement of students' conceptual understanding and academic performance in acid–base concepts. Figure 1 shows the interconnected concepts that emerged from the theoretical framework.

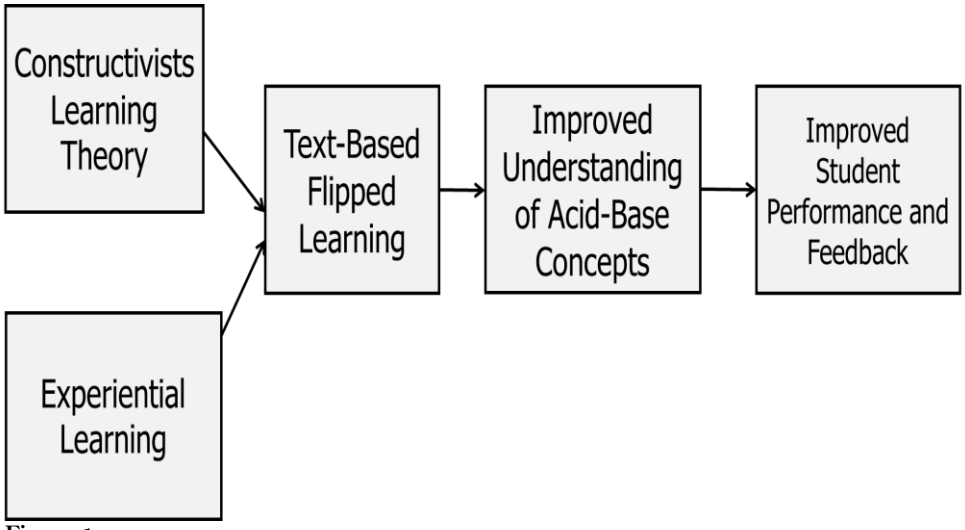

Figure 1.
Interconnected concepts emerged from the theoretical framework.

3.1. Research Question

To what extent does the text-based flipped learning approach enhance students' achievement in acid–base concepts at Ada Senior High Technical School?

4. Methodology

4.1. Research Design

The study employed a quantitative, quasi-experimental one-group pre-test/post-test design**,** which is appropriate in educational contexts where random assignment is not feasible [32]. This model allowed measurement of student performance before and after the intervention, providing evidence of its effectiveness [33]. Researchers use a quasi-experimental design to study the effects of treatment or interventions without randomly assigning learners to groups. Whole classes are normally used to compare results before and after an intervention. This research method is used in real-life settings like educational institutions, where it is difficult to assign participants randomly [34]. Another benefit is that researchers assess the effectiveness of teaching methods in authentic learning environments [35].

4.2. Population and Sample

According to Creswell and Creswell [36], a group of individuals who share common characteristics is considered the population and is of interest to the researcher. The small group studied is called a sample, but the results represent the entire population. The study targeted all Agricultural Science students offering Chemistry at Ada Senior High Technical School, with the accessible population being third-year students who had studied "Acid-Base Concepts" in their second year. A sample of 21 students was selected using the cluster sampling technique. According to Cohen [37], cluster sampling is a technique in which entire groups or "clusters" within the population are selected as the sample, rather than individual members. This sampling method allowed the researchers to select entire classes (clusters) of students rather than individuals for the study.

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ISSN: 2576-8484
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4.3. Data Collection Instruments

The study utilized a pre-test and post-test to assess students' understanding of acid-based concepts, with the pre-test serving as a baseline and the post-test measuring learning gains. A pre-test is given to participants in a study to determine their initial knowledge on a particular topic before the intervention. This assists the researcher in understanding the participants' level of knowledge before the intervention begins. However, a post-test is administered after the intervention to determine whether there has been an improvement in performance [38]. Pre-test and post-test are crucial in this study because they help evaluate participants' performance before and after the intervention [39]. This facilitates analysis of whether the intervention influenced performance and if it was successful. Additionally, a Likert-scale survey, adapted from Bennett et al. [40], was used to capture students' perceptions of the flipped learning experience. The instruments underwent validation by senior chemistry educators and methodology specialists to confirm both content and construct validity.

4.4. Data Collection and Analysis Procedure

The research used a six-week sequential data collection method. The pre-test assessment took place during Week 1. The instructional intervention occurred during Weeks 2 through 5. Confidentiality was maintained, and students' responses were coded without identifiable information. The post-test and survey administration took place during Week 6. The data collected were analyzed using descriptive statistics, and a paired-samples t-test was employed for inferential analysis in IBM SPSS version 27 to determine if there was a statistically significant change between pre-intervention and post-intervention mean scores at $\alpha = 0.05$ significance level. This test is suitable for within-subjects designs to assess whether observed performance changes result from the instructional approach rather than random chance [41]. The effect size of the intervention was measured through Cohen's d calculation, providing information about the practical significance of the intervention's impact [37], and a one-sample t-test was used to analyze perception scores.

4.5. Validity and Reliability

Methodological rigor was adopted in several procedures to establish the validity and reliability of the research instrument. For Test-Retest Reliability, the same student group took the pre- and post-test, but the test items were reviewed for stability and consistency. Instruments were reviewed by curriculum experts to ensure content validity aligned with the intended learning purpose. A pilot was conducted using a group of learners who were not involved in the main study to identify ambiguities and improve item clarity. Cronbach's alpha coefficient of 0.84 was used to analyze the pilot instrument's reliability. Threats to internal validity, such as instrumentation bias and testing effects, were mitigated by these measures.

According to Song et al. [42], Cronbach's alpha coefficients from 0.80 to 0.89 are acceptable for reliability and good for research purposes. Therefore, the instruments used in this study were reliable. The measures enhanced methodological rigor and reduced potential threats to internal validity, such as testing effects and instrumentation bias.

5. Results

This part highlights the findings of the study and places them within the context of existing research. Two tables were used to present the results: Table 1 describes the participants' demographic profile, and Table 2 shows the Pre-test and Post-test scores obtained in the study.

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Table 1.
Characteristics of Students and Their Prior Knowledge of Flipped Learning.

Variable		N	Percent (%)
Gender	Male	14	66.7
	Female	7	33.3
Age Group	Under 15 years	1	4.8
	15-17 years	3	14.3
	18-20 years	17	81.1
Prior Knowledge	No	18	85.7
	Yes	3	14.3

Table 1 indicates that the majority of participants were male (66.7%), and one-third of the sample was female (33.3%) according to the demographic profile. Many students (81.1%) were in the age group of 18-20 years, with smaller groups in the 15-17 years (14.3%) and below 15 years (4.8%). Eight point five percent of participants reported having no prior familiarity with the flipped learning approach, while 14.3% had previous exposure. Most participants were older secondary school students, and the flipped learning method was a relatively new instructional experience for them.

Table 2.
Pre-test and Post-test Scores on Acid–Base Concepts.

Variables	*N*	Mean	SD	Standard error of the mean	*CI95 of Mean Diff*	*T*	*df*	*P*	Cohen *(d)*
Pre-test	21	10.33	3.967	0.866					
					-7.140, -3.812	-6.87	20	**	3.655
Post-test	21	15.81	2.316	0.505					
Mean Difference				-5.476					

Comparing pre-test and post-test scores in Table 2, there was a statistically significant difference between students' performance after the intervention. Students achieved a mean score of 10.33 (SD=3.97) on the pretest and a mean score of 15.81 (SD=2.32) on the post-test. -5.48 points was the difference between the means of the two tests, with a 95% confidence interval ranging from -7.14 to -3.81. The negative sign (-) indicates higher post-test scores. The difference was highly significant, confirmed by a paired-samples t-test ($t_{(20)} = -6.87$, $p < 0.001$). There was a larger effect size (Cohen's d = 3.66), and a substantial improvement in academic performance after the intervention, as validated by the findings.

6. Discussion

6.1. Performance of Students Regarding Acid-Base Concepts

Table 1 provides important insights into students' baseline understanding before the instructional approach intervention on acid-base concepts. Students possessed a moderate understanding of the topic, reflected by the mean score of 10.33 (SD = 3.97), with some relatively higher scores and others struggling significantly. The approximate normality of the distribution (skewness = -0.018) and the score range (3 to 18) are consistent. These findings support literature indicating students find learning acid-base chemistry difficult in areas with limited resources [43, 44].

Acid-base theory requires students to learn abstract models such as Bronsted-Lowry, Arrhenius, and Lewis frameworks, demanding critical thinking because of their reliance on symbolic representation and theoretical abstraction [45, 46]. These align with findings at Ada Senior High Technical School, where students memorize and demonstrate a difficult understanding of concepts. Students who scored above 15 support the argument that traditional lecture methods do not provide enough support for conceptual development [47, 48].

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ISSN: 2576-8484
Vol. 10, No. 7: 37-46, 2026
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Overcrowded classrooms, limited training, and inadequate teaching materials are systemic challenges in Sub-Saharan Africa that worsen these learning barriers [49, 50]. The uneven distribution of scores observed, caused by these constraints, is reflected in the study. Low scores (3–5 points) in 14.4% of students suggest not only gaps in knowledge but also potential misconceptions that remain unaddressed due to ineffective instructional delivery. Misconceptions are often deeply rooted and require instructional designs that promote active engagement and individualized pacing to be overcome [51, 52].

The pretest results confirm that acid-base concepts create significant learning difficulties for secondary school students, particularly in low-resource educational settings, according to existing literature. The moderate mean score, together with the wide range of scores and the small number of high achievers, indicates an immediate need for educational changes. The collected data confirm the necessity of implementing different teaching methods, including flipped learning, to improve student understanding, self-directed learning, and academic results in complex chemistry subjects.

6.2. Performance of Students after Participating in Flipped Learning

The flipped learning intervention led to a substantial improvement in student performance on acid–base concepts because their post-test mean score reached 15.81 (SD = 2.32) after starting from 10.33. The post-intervention standard deviation was low, indicating that students achieved higher scores while their understanding of concepts became more uniform. The distribution maintained its normal shape (skewness = −0.118), confirming that the entire cohort achieved performance gains without significant outliers or disparities. This improvement was statistically validated through a paired-sample t-test, which yielded a highly significant result ($t(20) = -6.87$, $p < 0.001$) and an exceptionally large effect size (Cohen's $d = 3.66$), confirming the educational impact of the intervention.

Flipped learning is an effective teaching approach as it's a growing body of evidence supported by literature, with findings aligning with teaching abstract chemistry concepts. According to Hartandi and Mawardi [46] and Yu et al. [53], flipped classroom models improve both academic performance and long-term retention of content in acid-base chemistry. Students assimilate complex theoretical models like Brønsted-Lowry and Lewis acid-base frameworks at their own pace because of pre-class engagement with instructional texts followed by in-class application, which provides cognitive scaffolding. Constructivist learning theory, which posits that knowledge is best constructed through active and student-centered engagement, aligns with the flipped learning approach [1, 54].

Video dominates most flipped learning research, and the use of text-based materials in this context represents a critical innovation. This approach is possible for equitable flipped learning benefits because of digital infrastructure limitations in Sub-Saharan Africa, according to Aidoo et al. [55] and Eichler [56]. The post-test gains indicate that text-based materials proved both practical and educationally valid. The flipped learning method helped students overcome internet instability challenges while maintaining the necessary cognitive engagement and autonomy needed to master acid-base concepts. Text-based flipped learning works effectively in low-resource secondary schools because it matches the context and produces validated academic results.

7. Conclusion

The study examined the effect of a text-based flipped learning method on students' performance and engagement in acid-base concepts at Ada Senior High School. The results showed that the pretest of students' academic performance was moderate, with notable variation in individual performance, indicating difficulties in understanding abstract acid-based concepts. Students' academic performances improved significantly after the intervention with the flipped learning approach. This approach produced a statistically significant effect, demonstrating its strong impact on conceptual understanding. It can be established that students showed positive attitudes toward the text-based flipped learning approach. This approach helps them engage naturally in class activities. Such natural engagement highlights the importance of pre-class materials and support provided by the teacher. Therefore, it can

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ISSN: 2576-8484
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be said that a text-based flipped learning approach can significantly improve both academic performance and learner engagement. This offers a practical and effective pedagogical strategy for low-resource secondary school environments.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

References

[1] L. S. Vygotsky, *Mind in society: The development of higher psychological processes*. Cambridge, MA, USA: Harvard university press, 1978.

[2] I. Buabeng and B. Amo-Darko, "Curriculum reforms without foundation: The effects of inadequate preparation in curriculum reforms on Ghanaian teachers and the education system," *Curriculum Perspectives*, vol. 45, no. 2, pp. 133-147, 2025. https://doi.org/10.1007/s41297-025-00309-7

[3] A. Amegah, "Re-Imagining policy discourses concerning the participation of young women in STEM-related TVET in Ghana," *Journal of Vocational Education & Training*, vol. 76, no. 4, pp. 863-886, 2024.

[4] D. S. Fussy, H. Iddy, J. Amani, and S. T. Mkimbili, "Girls' participation in science education: Structural limitations and sustainable alternatives," *International Journal of Science Education*, vol. 45, no. 14, pp. 1141-1161, 2023.

[5] K. N. Mpuangnan, "Teacher preparedness and professional development needs for successful technology integration in teacher education," *Cogent Education*, vol. 11, no. 1, p. 2408837, 2024.

[6] S. D. Boateng, D. A. Ankrah, and S. A. Manteaw, "Competence-based education: Reflections on the context of teaching agriculture in Ghana's pre-tertiary schools," *Cogent Education*, vol. 10, no. 1, p. 2207793, 2023. https://doi.org/10.1080/2331186X.2023.2207793

[7] E. S. Jang and K. S. Oh, "Investigation of the influence of flipped learning and text-based generative artificial intelligence in programming education: Effectiveness and pedagogical strategies," *Computer Applications in Engineering Education*, vol. 34, no. 1, p. e70146, 2026.

[8] C. J. Crowder, R. Komperda, K. Bliss-Roche, and J. R. Raker, "Student perceptions of a flipped second-semester postsecondary organic chemistry course through the lens of the community of inquiry framework," *Chemistry Education Research and Practice*, 2026.

[9] C. Essiam, O.-A. Doris, and C. Quayson, "Are chemistry topics difficult to learn? the stance of Ghanaian senior high school students," *International Journal of New Trends in Arts, Sports & Science Education*, vol. 12, no. 2, pp. 112-121, 2023.

[10] A. Sortwell, E. Gkintoni, J. Díaz-García, P. Ellerton, R. Ferraz, and G. Hine, "Beyond cognitive load theory: Why learning needs more than memory management," *Brain Sciences*, vol. 16, no. 1, p. 109, 2026. https://doi.org/10.3390/brainsci16010109

[11] A. Iyamuremye, I. Twagilimana, and F. N. Niyonzima, "Examining the utilization of web-based discussion tools in teaching and learning organic chemistry in selected Rwandan secondary schools," *Heliyon*, vol. 10, no. 20, p. e39356, 2024.

[12] M. Paristiowati, T. Hadinugrahaningsih, A. Purwanto, and P. Karyadi, "Analysis of students' scientific literacy in contextual-flipped classroom learning on acid-base topic," in *Journal of Physics: Conference Series (Vol. 1156, No. 1, p. 012026)*. *IOP Publishing*, 2019.

[13] M. A. A. Aziz, O. Talib, T. Sulaiman, and N. Kamarudin, "The implementation of flipped classroom instructional to enhance academic achievement among form four chemistry students," *International Journal of Academic Research in Business and Social Sciences*, vol. 9, no. 7, pp. 967-980, 2019. https://doi.org/10.6007/IJARBSS/v9-i7/6195

[14] Rusmansyah, I. Bakti, H. Sasmita, A. Hamid, M. N. Aufa, and A. E. Kusuma, "Implementation of the flipped classroom-edmodo model to improve SRL and student learning outcomes," in *AIP Conference Proceedings (Vol. 3116, No. 1, p. 070028)*. *AIP Publishing LLC*, 2024.

[15] Y. Yerimadesi, B. Bayharti, A. Azizah, L. Lufri, A. Andromeda, and G. Guspatni, "Effectiveness of acid-base modules based on guided discovery learning for increasing critical thinking skills and learning outcomes of senior high school student," in *Journal of Physics: Conference Series (Vol. 1185, No. 1, p. 012151)*. *IOP Publishing*, 2019.

[16] R. Hanson and N. Seheri-Jele, "Assessing conceptual change instruction accompanied with concept maps and analogies: A case of acid-base strengths," *Journal of Turkish Science Education*, vol. 15, no. 4, pp. 55-64, 2018.

[17] K. Adu-Gyamfi, "Pre-service teachers' conception of an effective science teacher: The case of ınitial teacher training," *Journal of Turkish Science Education*, vol. 17, no. 1, pp. 40-61, 2020.

[18] Z. A. Bhat and G. J. Bhat, "Flipped classroom method in contemporary teaching learning environment," *Online Submission*, vol. 7, pp. 636-643, 2018.

[19] D. L. Santos and S. R. Mooring, "Characterizing mindset-related challenges in undergraduate chemistry courses," *Journal of Chemical Education*, vol. 99, no. 8, pp. 2853-2863, 2022. https://doi.org/10.1021/acs.jchemed.2c00270

[20] J. Lipscher, "Reflections on challenges and rewards in teaching chemistry," *Chimia*, vol. 77, no. 10, pp. 659-662, 2023. https://doi.org/10.2533/chimia.2023.659

[21] P. Chowdhury, R. Mp, S. Simelane-Mnisi, and O. On, "Attitude and performance: A universal co-relation, example from a chemistry classroom," *Turkish Journal of Science Education*, vol. 17, no. 4, pp. 603-616, 2020. https://doi.org/10.36681/TUSED.2020.48

[22] L. G. Hassan and M. Salihu, "Application of innovative methods to enhance the teaching and learning of chemistry," *Sokoto Educational Review*, vol. 19, no. 1, pp. 108-122, 2020.

[23] J. Kimani, "Instructional methods challenges and their influence on performance of chemistry among students with blindness in Rwanda: A critical literature review," *Journal of Chemistry*, vol. 1, no. 1, pp. 33-45, 2022. https://doi.org/10.47672/jchem.1098

[24] M. Sablić and A. Mirosavljević, "Possibilities for improving teaching practice through the application of inquiry-based learning," *Školski vjesnik: časopis za pedagogijsku teoriju i praksu*, vol. 73, no. 2, pp. 87-100, 2024.

[25] K. Lenggogeni and M. Mawardi, "Effectiveness of a flipped classroom based on guided inquiry learning system on acid-base solutions," *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 4, pp. 1874-1881, 2022.

[26] T. Muir, "Flipping the learning of mathematics: Different enactments of mathematics instruction in secondary classrooms," *International Journal for Mathematics Teaching and Learning*, vol. 20, no. 1, pp. 18-32, 2019. https://doi.org/10.4256/ijmtl.v20i1.139

[27] F. Finkenberg and T. Trefzger, "Flipped classroom in secondary school physics education," *Journal of Physics: Conference Series*, vol. 1286, 2019. https://doi.org/10.1088/1742-6596/1286/1/012015

[28] G. Cheng and W. S. Ng, *Secondary students' views on using flipped classroom to learn computer programming: Lessons learned in a mixed methods study*. Singapore: Springer Singapore., 2019.

[29] L. Ozgonul and M. K. Alimoglu, "Comparison of lecture and team-based learning in medical ethics education," *Nursing Ethics*, vol. 26, no. 3, pp. 903-913, 2019. https://doi.org/10.1177/0969733017731916

[30] B. Rogoff, *Apprenticeship in thinking: Cognitive development in social context*. New York, USA: Oxford University Press, 1990.

[31] C. A. Jerome, D. H. Lynn, and E. M. Simon, "Description of Tetrahymena empidokyrea n. sp., a new species in the Tetrahymena pyriformis sibling species complex (Ciliophora, Oligohymenophorea), and an assessment of its phylogenetic position using small-subunit rRNA sequences," *Canadian Journal of Zoology*, vol. 74, no. 10, pp. 1898-1906, 1996.

[32] L. Cohen, L. Manion, and K. Morrison, *Research methods in education*. London, United Kingdom: Routledge, 2018.

[33] F. M. Almutairi, A. A. Almodaires, and A. J. Zeyab, "Effectiveness of flipped learning: Improving pre-service teachers' prowess in producing videos," *International Education Studies*, vol. 13, no. 7, pp. 163-176, 2020.

[34] A. Singh, "Quasi experimental design in scientific psychology," *SSRN Electronic Journal*, 2021. https://doi.org/10.2139/ssrn.3793568

[35] O. Z. Jelena and M. Jelena, "Quasi-experimental research as an epistemological-methodological approach in education research," *International Journal of Cognitive Research in Science, Engineering and Education*, vol. 10, no. 3, pp. 177-183, 2022.

[36] J. W. Creswell and J. D. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*, 5th ed. Thousand Oaks, CA, USA: SAGE Publications, 2018.

[37] J. Cohen, *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ, USA: Lawrence Erlbaum Associates, 1988.

[38] C. Kongkaew, C. N. Scholfield, T. Supapaan, C. Mann, P. Mongkhon, and S. Chanunun, "Impact of research-based learning on student knowledge and assessment in Pharmacoepidemiology: A one group pretest-posttest experimental study," *Thai Journal of Pharmaceutical Sciences*, vol. 43, no. 4, pp. 236-241, 2020.

[39] S. J. Chang, K.-e. Lee, E. Yang, and H. Ryu, "Evaluating a theory-based intervention for improving eHealth literacy in older adults: A single group, pretest–posttest design," *BMC Geriatrics*, vol. 22, no. 1, p. 918, 2022. https://doi.org/10.1186/s12877-022-03545-y

[40] C. L. Bennett *et al.*, "First-year Wilkinson microwave anisotropy probe (WMAP) observations: Foreground emission," *The Astrophysical Journal Supplement Series*, vol. 148, no. 1, pp. 97-117, 2003.

[41] A. Field, *Discovering statistics using IBM SPSS statistics*, 5th ed. London, UK: SAGE Publications, 2018.

[42] H. Song, N. Lu, J. Wang, P. W. Lau, and P. Zhou, "Validity and reliability of the movement behaviour questionnaire child in Chinese preschoolers," *Frontiers in Pediatrics*, vol. 13, p. 1544738, 2025.

[43] Z. Naz and I. Mushtaq, "Conceptual difficulties of secondary school students in understanding acid-base chemistry," *Pakistan Journal of Social Research*, vol. 4, no. 1, pp. 422-428, 2022.

[44] D. N. Putri and A. Wiyarsi, "Identification of mental models of high school students on acid-base theory," in *AIP Conference Proceedings (Vol. 2468, No. 1, p. 040009). AIP Publishing LLC*, 2022.
[45] S. Ardianti, W. Wiji, and T. Widhiyanti, "Conceptions and troublesome knowledge on acid-base using the two-tier multiple-choice diagnostic test," in *Journal of Physics: Conference Series (Vol. 2098, No. 1, p. 012032). IOP Publishing*, 2021.
[46] M. Hartandi and M. Mawardi, "Effectiveness of the guided inquiry-based flipped classroom learning system on buffer solution materials on students' learning outcomes," *Jurnal Kimia Dan Pendidikan Kimia*, vol. 7, no. 2, pp. 194-207, 2022.
[47] C. G. Ekpo, U. S. Anaduaka, and B. Obaseki, "Effect of flipped classroom instructional strategy on students' academic achievement in chemistry in senior secondary schools in Federal Capital Territory, Abuja," *International Journal of Research in Education and Sustainable Development*, vol. 5, no. 1, pp. 48–57, 2025.
[48] S. M. Yusof, N. F. Razak, and I. Zakaria, "The assessment and preference of student-centered learning under subject of chemistry among PERMATApintar students," *e-BANGI*, vol. 21, no. 1, pp. 100-111, 2024. https://doi.org/10.17576/ebangi.2024.2101.09
[49] P. A. Okebukola *et al.*, "Delivering high school Chemistry during COVID-19 lockdown: Voices from Africa," *Journal of Chemical Education*, vol. 97, no. 9, pp. 3285-3289, 2020. https://doi.org/10.1021/acs.jchemed.0c00725
[50] A. Zickafoose *et al.*, "Barriers and challenges affecting quality education (Sustainable Development Goal# 4) in sub-Saharan Africa by 2030," *Sustainability*, vol. 16, no. 7, p. 2657, 2024. https://doi.org/10.3390/su16072657
[51] S. Haryani, S. Dewi, and A. Harjito, "The effectiveness of the refutation text to improve understanding of the acid-base concepts for high school students," *Periodico Tche Quimica*, vol. 17, no. 36, pp. 766–783, 2020.
[52] C. Dewi, P. Pahriah, and A. Purmadi, "The urgency of digital literacy for generation Z students in chemistry learning," *International Journal of Emerging Technologies in Learning*, vol. 16, no. 11, pp. 88-103, 2021. https://doi.org/10.3991/ijet.v16i11.19871
[53] L. Yu, Y. Li, Y. Lan, and H. Zheng, "Impacts of the flipped classroom on student performance and problem solving skills in secondary school chemistry courses," *Chemistry Education Research and Practice*, vol. 24, no. 3, pp. 1025-1034, 2023.
[54] J. Sweller, "Cognitive load during problem solving: Effects on learning," *Cognitive Science*, vol. 12, no. 2, pp. 257-285, 1988.
[55] B. Aidoo, C. Anthony-Krueger, A. O. G. Gyampoh, J. Tsyawo, and F. Quansah, "A mixed-method approach to investigate the effect of flipped inquiry-based learning on chemistry students learning," *European Journal of Science and Mathematics Education*, vol. 10, no. 4, pp. 507-518, 2022. https://doi.org/10.30935/scimath/12339
[56] J. F. Eichler, "Future of the flipped classroom in chemistry education: Recognizing the value of independent preclass learning and promoting deeper understanding of chemical ways of thinking during in-person instruction," *Journal of Chemical Education*, vol. 99, no. 3, pp. 1503-1508, 2022.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 10, No. 7: 37-46, 2026
DOI: 10.55214/2576-8484.v10i7.13197