



*Qualitative Study on ... Umate, B. A., Et. al. (2025)*

## Qualitative study on Collaborative Instructional Strategies on Academic Performance in Chemistry: A Systematic Approach

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### Abstract

*This paper examines the efficacy of collaborative learning approach in improving learner's academic performance in the field of chemistry. Collaborative learning is centered on peer-to-peer engagement and group activities. It has emerged as a potent pedagogical tool to foster deeper understanding and retention of chemical concepts. Common examples of collaborative learning strategies are jigsaw teaching strategy, peer teaching, problem-solving tasks, and project-based learning, among others. Research has established that this learning strategy has a positive impact on learners' cognitive development, logical thinking strategies, and academic performance. Additionally, the review has shown that collaborative learning approaches can be facilitated by using Information and Communication Technologies such as online collaboration platforms, virtual laboratories, and video conferencing platforms. Although collaborative learning approaches offer advantages, literature has also reported challenges specific to this learning strategy in teaching and learning of chemistry. This paper discusses these challenges and offers corresponding solutions. In conclusion, collaborative learning serves as a powerful catalyst for improving students' academic performance.*

**Keywords:** performance, Collaborative learning, chemistry; Information and Communication Technologies

### Introduction

Chemistry is the scientific study of chemical of matter, and the transformation it undergoes. According to Nnoli (2014), chemistry is an important discipline of science that enables the learner to have an environmental awareness. Chemistry is the basic key and gateway to modern technology (Okafor, 2022). At the local and worldwide levels, chemistry is a tool for national development. Anugwo et al. (2023) state that it is crucial in a variety of specialized fields, including industries, agriculture, transportation, housing, medicine, and engineering. According to Attahiru, Haruna, and



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Abubakar (2020), chemistry contributes to the provision of clean energy and a healthy environment for sustainable development and may be utilized to fight insecurity by, for example, identifying and classifying compounds found at crime scenes. According to Abdullahi, Lawal, and Isah (2020), chemistry knowledge may also be able to help reduce youth unemployment. In recognition of the importance of chemistry in development of a Nation, the National Policy on Science and Technology Education was developed by the Federal Government of Nigeria (FGN) in 2018 as part of its efforts to train competent science and technical teachers, including chemistry teachers. The policy's objective is to develop a vital scientific and technology workforce in Nigeria that can elevate the country's economy to a global level (Policy on S & TE, 2018). In addition, FGN has given out special grants including the TETFund, capital grants, and recurrent grants. Training of science teachers, including chemistry teachers, is the goal of these special grants (Toluwalop, 2016). Science education (chemistry education) researchers have also worked to enhance the learners' academic success in chemistry at the secondary and undergraduate levels by utilizing creative teaching methods and intervention therapies. For instance, Victor-Aigbodion et al. (2023), Ezeudu et al (2019) and Tóth (2023), did an intervention using rational emotive behavior therapy on undergraduate chemistry education students to manage academic burnout and depression so as to improve their cumulative grade point average. Ugwuanyi et al. (2020) used cognitive behavior therapy as an intervention to manage undergraduate students' academic procrastination at some Nigerian universities. Some science education (chemistry education) researchers adopted ICT-based innovative teaching strategies in a bid to improve students' academic achievement at the undergraduate level. Okafor (2022) used a virtual learning environment in a bid to allow students to interact with learning activities and reduce difficulties with chemistry concepts. This would then enhance students' academic engagement and achievement. Kolil, Muthupalani, and Achuthan (2022) adopted virtual laboratory platforms to improve students' analytical skills and reduce their anxiety while performing experiments. This was done to enhance their engagement and performance.

Okafor (2022) used a Google Meet learning environment to allow chemistry education students to interact with learning activities in order to improve their understanding of difficult chemistry concepts and increase collaboration among them. This would then enhance their academic achievement. Kolil, Muthupalani, and Achuthan (2022) used virtual laboratory platforms to improve chemistry education students' analytical skills and reduce anxiety toward performing experiments. This was expected to improve their engagement in learning and performance. Considering the efforts made by FGN and science education researchers toward improving students' academic achievement from secondary school level up to the undergraduate level, it is expected that students should demonstrate high academic achievement. According to Umate, Aminu and Hamza (2018), academic achievement is the knowledge, competencies or skills acquired by students in a school subject which is determined by the grades assigned by teachers, schools or examination bodies. Academic achievement at secondary school level is interpreted based on raw scores such as percentage pass or fail as well as standard scores such as Z-scores, T-score, Standard of Nine (STANINE). Academic achievement at university level is measured and interpreted as the Cumulative Grade Point Average (CGPA). CGPA is obtained by the scores on tests, assignments, practical work, examination, and lecture attendance of every student (Lawal, 2014). The Nigerian university system grades students' CGPA on a 5-point scale ranging from first class (4.50–5.00), second class honors (upper division) (3.50–4.49), second class honors (lower division) (2.40–3.49), third class honors (1.50–2.39), and v) pass degree (1.00–1.49). Because of the importance of chemistry in the technological advancement of any nation, as well as efforts made by FGN and science education or chemistry education



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researchers, it is expected that students will perform very well from secondary school level up to university level. However, studies reported that students perform unsatisfactorily both at the secondary school and university levels. According to the WAEC Chief Examiners' report from 2017–2021, chemistry students' performance fluctuated, and most show performance below 50%. Badmus and Omosewo (2018) also reported that students' performance in chemistry from 2007 to 2017 was below 50% except for 2013, 2014, and 2015, which were 72%, 62%, and 60%, respectively. In addition, WAEC Chief Examiners' Report for 2018-2023 revealed that chemistry students' performance has not been satisfactory. The students' CGPA at undergraduate level has been reported to be low in both private and public universities (Okafor, 2022; Eya, Okebannama, & Umate, 2020; Akunne, 2020). Furthermore, statistics of the chemistry education students' records in some Nigerian universities show that more than 50% of chemistry education students do not always graduate by the stipulated time.

Some researchers reported that the use of inappropriate instructional strategies in the teaching and learning of chemistry is the major contributory factor that led to unsatisfactory academic performance in chemistry from secondary school level up to university level. In order to resolve this issue of unsatisfactory performance, an innovative teaching strategy that provides learners with opportunities for manipulating learning activities individually and collaboratively should be adopted, as reported by Umate, Ahmad, and Ibrahim, (2021). One of the trending skills and competencies of the 21st century is working together to complete a task or offer a solution to a problem. One of the innovative teaching strategies that provides these opportunities to students is collaborative learning. Collaborative learning is a group of teaching strategies that allows groups of students to perform educational tasks. It allows individuals' active engagement and discussion in a coordinated manner to perform task, or reconstruct shared knowledge (Darko & Wang, 2021). It is an umbrella term for various instructional approaches to small group learning, including team-based learning, peer tutoring, study groups, project-based learning, problem-based learning, and learning communities (Yang, 2023). Collaboration refers to the interaction among peers where individuals are mindful of their actions, which include learning, contributing and respecting one another. According to this approach, in any group setting, individuals' abilities, skills, strength and input are taken into consideration. This suggests that group shared authority and holds joint responsibility for its decisions and outcomes (Niyonsaba, Nkurunziza, & Hakizimana, 2022). Center for Teaching Innovation of Cornell University (2023) reports that collaborative learning helps in advancing higher order thinking, communication skills, self-regulation, and administrative skills. It also helps in espousing learners to diverse perspectives, improve their understanding of concepts, prepares them for real life situations. There has been considerable research carried out on the effectiveness of this approach in improving students' academic achievement.

In Ghana, Darko and Wang, (2021) found that collaborative learning improved undergraduate business education students' learning and attitude. Ajayi and Ajayi (2020) reported that the collaborative learning strategy improves undergraduate students' learning success in science education. Niyonsaba, Nkurunziza, and Hakizimana (2022) revealed that Rwandan chemistry students exposed to chemistry contents using collaborative learning performed significantly better than those taught using traditional methods of teaching. Priyambodo, Fitriyana, Primastuti, and Artistic (2020) found that collaborative learning enhanced Indonesian learners' motivation as well as performance. Chang, Yan, and Lu (2022) reported that collaborative learning enhanced Taiwan students' academic performance in a programming course. Aku, Hussaini, and Gabi (2022) found



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that students taught concepts of energy using collaborative learning in Nasarawa state have high scores than with conventional methods of teaching. Research have established that collaborative learning helps in improving students' academic achievement. However, most of the studies were conducted with students from other nations, and some were carried out with students from area specializations such Physics, Business Education, computer science, among others. Most importantly, the use of collaborative learning is especially limited in the field of chemistry education despite its advantages and efficacy in improving academic achievement. From the foregoing, the unsatisfactory academic achievement among chemistry students from the secondary school level up to the university level has been a persistent problem that has left educational stakeholders in Nigeria worried. This is because chemistry is a vital tool for national development and technological advancement. The use of innovative teaching strategies such as collaborative learning approach can help chemistry students manipulate learning activities on an individual basis as well as on a group basis. This leads to improvements in students' academic achievement, retention, and collaboration. This in turn can help in resolving chemistry students' unsatisfactory academic achievement.

**Statement of the Problem**

As noted earlier, chemistry is a vital tool for the technological advancement of any nation and the world at large. Despite the roles chemistry plays in national development and daily activities, reports from WAEC Chief Examiners and some researchers revealed that students' performance in chemistry at secondary school has been unsatisfactory. At the undergraduate level, students' CGPA has been reported to be low in both private and public universities. Moreso, statistics of chemistry education students' records in some Nigerian universities show that more than 50% of chemistry education students do not always graduate by the stipulated time. (Umate, 2024). The federal government of Nigeria and science education researchers have made a lot of efforts to make sure that students perform better in their academic endeavors from secondary school up to undergraduate levels. This was done by establishing science and technical boards, developing policies, and carrying out research projects aimed at improving learners' performance, among others. Nevertheless, students' performance in chemistry from secondary level to undergraduate levels continues to be low.

If students' low academic performance in chemistry continues, it would pose a threat to the production of prospective science students who would study science-related areas of specialization such as medicine and pharmacy as well as the production of chemistry teachers in secondary schools and other tertiary institutions. This, in turn, will hinder the production of scientists and the technical workforce that are required to transform the nation's economic landscape into a world class economy. Researchers reported that the inability to adopt innovative instructional strategies such as collaborative learning is the major contributory factor for unsatisfactory students' academic performance in chemistry. Much research has been conducted on the relative effects and efficacy of collaborative learning in improving students' learning outcomes. Most of these studies used foreign samples whose results might not be generalizable to the Nigerian context, some of them were carried out with students from disciplines other than chemistry, and some used a limited sample size that might not generalize to other populations. These are the gaps that call for this study. Therefore, the problem of this study put in question form is: Would collaborative learning be a stimulus for improving students' academic performance in chemistry?

**Theoretical Framework**

This review is anchored on Socio-cultural Theory by Lev Vygotsky (1978). This theory was developed by Lev Vygotsky (1978). It posits that learning is a social process wherein individuals construct knowledge through interactions with others. According to Vygotsky, learners can achieve higher



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levels of understanding by engaging in collaborative activities, such as problem-solving, discussion, and joint projects. Social-cultural theory involves three key concepts: zone of proximal development, scaffolding, and internalization. Zone of Proximal Development (ZPD): Central to socio-cultural theory is the concept of the Zone of Proximal Development, or ZPD. This is the difference between what a learner can do independently and what they can achieve with the guidance and support of a more knowledgeable other, such as a teacher, peer, or parent. Vygotsky argued that learning should occur within the ZPD, as it allows for the scaffolding of learning experiences, leading to the development of higher-order thinking skills.

**Scaffolding:** Scaffolding refers to the support provided by a more knowledgeable other to help learners bridge the gap between their current level of understanding and their potential developmental level within the ZPD. This support can take various forms, such as modeling, prompting, questioning, and providing feedback. Through scaffolding, learners gradually internalize and master new concepts and skills. **Internalization:** According to socio-cultural theory, learning involves the internalization of cultural tools and practices through social interaction and participation in cultural activities. Through collaborative activities and guided instruction, learners gradually internalize the knowledge, skills, and strategies of their cultural community, transforming external social processes into internal cognitive processes.

### **Collaborative Learning and students' academic performance**

Collaborative learning is a group of teaching strategies that involves the coming together of students in groups with an aim of achieving or completing a task. Ha Le (2018) defined collaborative learning as a set of teaching and learning strategies that promote students to work in small groups (two to five students) to complete tasks. This approach involves groups of students teaming together to perform or complete a task. Collaborative learning is “any form of learning that occurs due to social interaction between two or more individuals when they are working together on the same task or toward the same goal” (Naji & Croje, 2022). Collaborative learning is a group of teaching strategies whereby students work in groups to explore and manipulate learning activities. This could be a group of learners deliberating on class lessons or learners from different institutions of learning working virtually over the Internet to complete academic activities. It is based on the premise that learning occurs because of social interactions among the learners themselves, teachers, school and society. This approach allows students to actively engage in learning activities, process and synthesize information. They work in groups on projects, where everyone must contribute toward completing the project or assignment.

Collaborative learning comprises several approaches and strategies to teaching in education. It provides a platform for intellectual exercise between students, or students and their teachers. In this approach learners are put in small groups heterogeneously and monitored by their teacher(s) to perform or complete a task or academic activities (Lombardi, 2018). Collaborative learning helps learners to create both academic and social relationships to accomplish common goals and active control over their own learning process (Niyonsaba, Nkurunziza, & Hakizimana, 2022; Nkechinyere, Ordu, Harcourt, & Harcourt, 2018). According to Abubakar and Arshad (2015), collaborative learning helps in enhancing learners' learning and problem-solving skills. These problem-solving skills include communication, teamwork and high order thinking skills, among others. According to Leopold and Smith (2020) and Novita, Kurnia, and Mustofa (2020) collaborative learning has social, psychological and academic benefits. Social benefits include: i) developing social support for students, ii) building diverse understanding between students themselves and staff, iii) establishing



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a positive atmosphere for practicing cooperation and iv) developing learning communities. The Psychological benefits include i) increasing students' self-esteem, ii) Reducing anxiety among students iii) developing positive attitudes towards teachers. While Academic benefits: i) Promoting critical thinking, ii) encouraging students' active engagement and iii) motivating students to learn. Research has shown that collaborative learning approach is one of the vital tools that helps in improving students' academic performance. It is also one of the best teaching strategies that could be adopted for reducing abstractions and difficulties of some chemistry concepts (Abukari, et al., 2023). Chang, Yan and Lu (2022) reported that first year students of Taiwan University taught information management with collaborative learning exhibited higher improvements in academic performance. Abukari, et al., (2023) found that collaborative learning approach improved Ghanaian secondary school students' academic performance in organic chemistry. Achufusi-Aka and Okpanachi (2021) reported that collaborative learning strategy has a positive impact on learners' academic success in Chemistry compared to the conventional teaching method.

Adjei, Hanson, Sam, and Sedegah (2020) revealed that Ghanaian high school students taught redox reaction using collaborative learning had better academic achievement compared to those taught using conventional method of teaching. Kamanga and Shumba (2022) disclosed that Zambian pre-service chemistry teachers taught concept of environmental chemistry using collaborative learning demonstrated high academic performance. Kumar (2017) did a meta-analysis of effects of collaborative learning on the students' academic performance. The results revealed that collaborative learning has moderate effects on the students' academic performance. Jekayinfa, Durojaiye, and Oloda (2023) found that mathematics students taught with collaborative learning outperformed their counterparts taught with conventional teaching methods. Zambrano et al. (2019) disclosed that high-school Ecuadorian students' academic performance in mathematics improved significantly after teaching them with collaborative learning approach. Gaad (2022) reported that Philippines students' exposure to the Collaborative learning strategy was effective in facilitating significant improvements in their achievement and engagement in physical science.

A careful analysis of the literature revealed that collaborative learning could be used as a stimulus for improving students' academic performance. However, most of these studies were carried out with samples of students from disciplines other than chemistry. Some studies were conducted with samples of foreign students whose result might not be generalizable to Nigeria. There is also scarcity of studies in the field of chemistry education that utilize collaborative learning in teaching chemical concepts. Therefore, this study is advocating that collaborative learning approaches should be adopted in teaching and learning chemistry. This might help in resolving unsatisfactory chemistry students' academic performance from secondary school level up to the university level.

### **Forms of Collaborative Learning**

Collaborative learning encompasses a variety of instructional methods and activities that promote interaction, cooperation, and shared knowledge construction among learners (Chang-Tik, 2022; Udvari-Solner, 2012; Laal, M., & Laal, M., 2012). Here are some common forms of collaborative learning:

1. **Group Discussions:** Group discussions involve learners engaging in conversations with their peers to explore concepts, share ideas, and deepen their understanding of the subject matter (Goshtasbpour, 2022). These discussions can be structured around specific topics, questions, or problems, and may take place in small or large groups, either in-person or online.



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2. Peer Teaching: Peer teaching involves students taking on the role of teachers to explain concepts, demonstrate skills, or facilitate learning activities for their classmates (Stigmar, 2016). This approach not only helps reinforce the material for the student teaching but also provides an opportunity for active engagement and learning for the entire group.
3. Collaborative Project: Collaborative projects require students to work together in groups to complete a task or solve a problem. These projects can take various forms, such as research projects, presentations, group reports, or creative productions. Collaborative projects encourage teamwork, communication, and the integration of diverse perspectives.
4. Jigsaw Technique: The jigsaw technique divides students into small groups, with each group member becoming an expert on a specific topic or aspect of a larger concept. After mastering their individual topics, students then reconvene in new groups composed of members from different initial groups, where they share their expertise to complete a comprehensive task or project.
5. Think-Pair-Share: Think-Pair-Share is a form of collaborative learning strategy that involves three steps: students first think individually about an academic task or question, then pair up discussing what was reflected on, and lastly share the ideas with the entire class. This approach promotes active participation and peer interaction.
6. Problem-Based Learning (PBL): In problem-based learning, students work in teams to solve relevant, real-world problems. PBL encourages inquiry the development of inquiry, problem-solving, and critical thinking skills. This occurs as students engage in self-directed learning and collaborative problem-solving.
7. Cooperative Learning Structures: Cooperative learning structures are instructional techniques designed to promote positive interdependence, individual accountability, collaborative skills, and group processing. Examples include the use of learning teams, reciprocal teaching, peer tutoring, and the use of roles and responsibilities within groups.
8. Student Teams-Achievement Divisions (STAD) is a collaborative learning framework in which students work in small groups to help master instructional content. According to Ishtiaq, Ali and Hussain (2020), this model consists of four stages: 1) direct instruction from the teacher, 2) collaborative teamwork, 3) individual quizzes and recognizing high achieving teams.

### **Strategies for Implementing Collaborative Learning in Chemistry**

As noted by the Graduate School of Education and Human Development, George Washington University (2024), adopting collaborative learning in teaching requires careful planning and the use of various strategies to promote engagement and foster meaningful interactions among students. When these strategies are properly and effectively implemented, educators can create a collaborative learning environment in chemistry that fosters active engagement, enhances understanding of concepts, and promotes the development of critical thinking and communication skills (Achufusi-Aka & Okpanachi, 2021). Here are some strategies for implementing collaborative learning in chemistry:

1. Group Formation: Strategically form groups to ensure diversity in terms of knowledge, skills, and backgrounds. Consider factors such as students' academic abilities, interests, and learning styles when forming groups to maximize collaboration and peer learning.
2. Clear Learning Objectives: Clearly define learning objectives for collaborative activities to provide students with a sense of purpose and direction. Align these objectives with the specific chemistry concepts or skills you want students to learn or reinforce through collaboration.
3. Role Assignments: Assign specific roles or responsibilities to each group member to ensure active participation and accountability. Roles may include facilitator, note-taker, timekeeper,



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researcher, or presenter. Rotate roles periodically to provide all students with opportunities to develop different skills

4. Use of Technology: Integrate technology tools and platforms to facilitate collaboration and communication among group members. Virtual collaboration tools, online discussion forums, shared documents, collaborative document editing (e.g MS DOC and collaborative whiteboards) can enhance interaction and engagement, especially in virtual or hybrid learning environments.
5. Real-World Applications: Incorporate real-world applications and examples into collaborative activities to make chemistry concepts more relevant and engaging for students. Encourage students to apply their knowledge to solve authentic problems or analyze real-life scenarios related to chemistry.
6. Feedback and Reflection: Provide opportunities for students to give and receive feedback on their collaborative work and reflect on their learning experiences. Encourage self-assessment and peer assessment to promote metacognitive skills and continuous improvement.
7. Teacher Support and Guidance: Offer guidance and support to students throughout the collaborative learning process. Be available to answer questions, clarify concepts, and provide assistance as needed. Monitor group interactions and intervene when necessary to address any challenges or issues that arise.
8. Assessment and Evaluation: Develop assessment criteria and rubrics that assess both individual and group performance in collaborative activities. Evaluate students based on their contributions to group discussions, problem-solving skills, teamwork, and the quality of their collaborative outputs. Provide constructive feedback to help students identify areas for improvement.

### **Tools and Technologies for Facilitating Collaborative Learning in Chemistry**

Some studies reported that collaborative learning can be greatly enhanced in chemistry with the use of various tools and technologies (Wohlfart, Wagner & Wagner, 2023; Iyamuremye, Mukiza, Nsengimana, 2023; Zamiri, & Esmacili, 2024). Some of these tools include:

1. Online Collaboration Platforms: Platforms like Google Workspace (formerly G Suite), Microsoft Teams, or Slack offer features like document sharing, real-time collaboration on documents, and communication channels. Students can collaborate on projects, share resources, and discuss concepts.
2. Virtual Laboratories: Virtual labs like ChemCollective, Labster, or PhET Interactive Simulations provide a safe environment for students to conduct experiments, explore chemical reactions, and visualize complex concepts. These tools often offer interactive simulations that mimic real laboratory experiences.
3. Video Conferencing: Platforms like Zoom or Skype can be used for virtual lectures, group discussions, and tutoring sessions. They allow for real-time interaction and screen sharing, enabling instructors to demonstrate experiments or explain concepts visually.
4. Online Whiteboards: Tools like Miro or Jamboard provide digital whiteboard spaces where students can brainstorm ideas, solve problems collaboratively, and visualize concepts. These platforms support drawing, writing, and importing images, making them versatile for chemistry-related activities.
5. Learning Management Systems (LMS): LMS platforms such as Moodle, Canvas, or Blackboard offer features for content delivery, discussion forums, quizzes, and assignment



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submissions. Instructors can organize course materials, track student progress, and facilitate discussions within the platform.

6. Interactive Multimedia Content: Websites like Khan Academy, ChemEd DL, or Chemguide offer interactive lessons, tutorials, and quizzes covering various chemistry topics. These resources engage students with multimedia content such as videos, animations, and interactive exercises.
7. Collaborative Document Editing: Tools like Google Docs or Microsoft Office Online enable real-time collaboration on documents, spreadsheets, and presentations. Students can work together on assignments, write reports, and provide feedback to each other seamlessly.
8. Online Assessment Tools: Platforms like Kahoot, Quizizz, or Socrative allow instructors to create interactive quizzes, polls, and surveys to assess student understanding. These tools make learning engaging and provide instant feedback to students.
9. Social media and Online Forums: Utilizing platforms like Reddit, Facebook Groups, or dedicated chemistry forums can foster community among students and provide a space for discussion, resource sharing, and peer support outside of the classroom.

Research has proven that by incorporating ICT tools and technologies into collaborative learning approach, instructors or teachers can create dynamic and interactive learning environments that foster collaboration, critical thinking, and deeper understanding of chemical concepts.

### **Challenges and Solutions in Collaborative Chemistry Learning**

Collaborative learning in chemistry has some challenges due to individual difference and diverse nature of the students. According studies (Wang, 2022; Irzawati, 2023; SciSpace, 2024) Some common challenges and potential solutions for collaborative chemistry learning include:

1. Complexity of Concepts: Chemistry involves intricate concepts and abstract theories that can be challenging to grasp. In a collaborative setting, some students may struggle to keep up with the pace or understand certain concepts.

**Solution:** Encourage peer teaching and group discussions. Breaking down complex topics into smaller, digestible chunks can help students understand better.

2. Diverse Learning Styles: Students have different learning styles and preferences. What works for one student may not work for another, leading to disparities in understanding and engagement.

**Solution:** use variety of teaching aids that cater to different learning styles, such as visual aids, hands-on activities, and interactive simulations.

3. Time Management: Balancing collaborative chemistry projects with other coursework and commitments can be challenging for students, leading to procrastination and rushed work.

**Solution:** Break down larger projects into smaller, manageable tasks with clear deadlines. Encourage students to set realistic goals and create a timeline for completing each task. Monitoring progress regularly and providing guidance can help students stay on track.

4. Communication Barriers: Effective communication is essential for successful collaboration, but misunderstandings and miscommunication can occur, especially in diverse groups.



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**Solution:** Foster open communication by establishing clear expectations and guidelines for collaboration. Encourage active listening, respectful feedback, and constructive criticism within groups, compromise, and conflict resolution, among others.

5. Technical Challenges: Performing experiments and conducting research often require access to specialized equipment and resources, which may not be readily available to all students.

**Solution:** Explore alternative methods, such as virtual simulations and online laboratories, to supplement traditional hands-on experiments. Encourage students to collaborate with peers who have access to different resources and equipment, promoting a diverse range of experimental approaches.

When these potential challenges are appropriately addressed, and proposed solutions are effectively implemented, collaborative chemistry learning can be a rewarding experience that enhances students' understanding of the subject, promoting critical thinking, communication, and teamwork skills (Ijirana, Supriadi, & Magfirah, 2022; SciSpace, 2024).

### **Conclusion**

Collaborative learning approach is a group of teaching strategies that allow students to work in small groups to achieve a common goal. It helps in improving students' academic performance. When it well planned and coordinated, it can also be used in improving students' academic performance in chemistry. This is done by fostering active engagement, peer interaction, and problem-solving skills. collaborative learning enhances students' understanding and appreciation of chemical concepts, ultimately leading to improved academic outcomes.

### **Recommendation**

Here are some recommendations specifically tailored for adopting collaborative learning in teaching chemistry:

1. Curriculum Integration: Integrate collaborative learning activities seamlessly into the chemistry curriculum. Identify topics or concepts that lend themselves well to group work, such as laboratory experiments, problem-solving sessions, or case studies.
2. Provide Clear Instructions: Clearly communicate the objectives, expectations, and guidelines for collaborative activities to students. Ensure they understand their roles within the group and the purpose of the task.
3. Utilize Cooperative Structures: Implement cooperative learning structures such as think-pair-share, jigsaw, or peer tutoring to facilitate effective collaboration among students. These structures provide clear frameworks for interaction and participation.
4. Encourage Peer Teaching: Foster a culture of peer teaching and learning within collaborative groups. Encourage students to explain concepts to each other, ask clarifying questions, and provide feedback on their peers' understanding.
5. Facilitate Group Discussions: Act as a facilitator during group discussions, guiding students through the problem-solving process while allowing them to take ownership of their learning. Encourage active listening, respectful dialogue, and consensus building within the group.
6. Promote Critical Thinking: Design collaborative activities that require students to apply critical thinking skills to solve real-world chemistry problems. Encourage them to analyze data, draw connections between concepts, and propose hypotheses collaboratively.
7. Provide Resources and Support: Offer resources, materials, and guidance to support students during collaborative activities. Provide access to relevant textbooks, online resources, or laboratory equipment as needed to facilitate their exploration and experimentation.



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8. Assess Collaboration Skills: Assess not only students' understanding of chemistry concepts but also their collaboration skills and contributions to group work. Use rubrics or peer evaluations to evaluate teamwork, communication, and problem-solving abilities.

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