

SKILL ENHANCEMENT IN COLLABORATIVE LEARNING: SIGNIFICANT SHIFT FROM TRADITIONAL TEACHER-CENTERED APPROACH

Dr. R. Ramyadevi

Assistant Professor, Department of Computer Science and Application, SRM Institute of
Science and Technology, Ramapuram, Chennai, Tamilnadu
ramyaresearch@gmail.com

Dr. G. Dheepa

Assistant Professor, Department of Computer Science and Applications, SRM Institute of
Science and Technology, Ramapuram, Chennai, Tamilnadu
dheepag@srmist.edu.in

R. Nithyadevi

Teaching Faculty, Faculty of Mathematics, Sri Chaitanya Techno School, Mangaluru,
Karnataka, nithya.thams@gmail.com

ABSTRACT

Collaborative learning is an approach to education that emphasizes working together in groups to achieve shared learning objectives. Skill identification is a key aspect of collaborative learning as it enables group members to assign tasks and responsibilities that leverage each other's strengths and expertise. In this research work, we will explore different strategies for identifying skills in collaborative learning. One strategy for skill identification is self-assessment. Group members can reflect on their own experiences, expertise, and personal qualities that may be useful in a collaborative learning environment. This strategy is useful for individuals who may be less comfortable sharing their skills with others and can help each member gain a better understanding of their own strengths and weaknesses. By actively listening to each other and sharing knowledge and perspectives, group members can identify areas where each person has expertise and can contribute to the group's learning objectives. This strategy can help members build a shared understanding of the group's strengths and can facilitate effective collaboration. Assignments and projects can provide opportunities for members to showcase their skills and strengths. By observing each other's work and contributions to the project, the group can identify each member's strengths and assign tasks that play to those strengths. This strategy can help members feel valued and appreciated for their unique skills and expertise.

Keywords: Collaborative learning groups; Need for cognition; Core self-evaluations; Group discussion quality; Group performance;

1. INTRODUCTION

a. Cooperative and Collaborative Learning

In the process of exploring an important question or developing a significant project, students work in groups as part of the teaching and learning process known as collaborative learning. Collaborative learning can take many different forms, such as students from several schools working together online to complete a group assignment. Cooperative learning, on the other hand, is a particular sort of collaborative learning. Students engage in structured activities in small groups as part of cooperative learning [1]. They are each responsible for their own work, and the group's collective work is also evaluated. Cooperative groups practise face-to-face collaboration and teamwork.

Certain crucial variables need to be taken into account in order to develop a setting conducive to cooperative learning. Students must first feel safe while being challenged [2]. Second, groups must be compact enough for everyone to participate. Lastly, the assignment that the class completes jointly must be precisely defined. Small groups in cooperative learning also offer a setting where:

- Students learn conflict-resolution techniques
- members draw on their prior experience and knowledge
- goals are clearly identified and used as a guidance
- research tools like Internet access are used
- Projects and questions interest and challenge students.

Creating a collaborative environment to impart life skills is an excellent way to help individuals develop the necessary skills to succeed in various aspects of life [3]. Here are some steps you can take to create a collaborative environment for teaching life skills:

- **Establish clear learning objectives:**

Begin by setting clear learning objectives for the group. These objectives should be specific, measurable, achievable, relevant, and time-bound. This will give the group a clear sense of direction and purpose.

- **Encourage communication:**

Communication is key to building a collaborative environment. Encourage open and honest communication among the group members, and ensure that everyone has the opportunity to share their thoughts and ideas.

- **Foster teamwork:**

Encourage teamwork by giving groups of people tasks that call for cooperation in order to accomplish a common objective. Collaboration abilities, such as conflict resolution, communication, and problem solving, will be improved as a result.

- **Provide feedback:**

Provide regular feedback to group members to help them understand their strengths and weaknesses. This will help them develop their skills and improve their performance.

- **Use technology:**

Use technology to facilitate collaboration and communication. There are several collaboration tools available, such as Google Drive, Trello, and Slack, that can help group members work together more efficiently.

- **Create a positive learning environment:**

Create a positive learning environment by promoting mutual respect and appreciation for each other's contributions. Encourage a growth mindset and celebrate successes, no matter how small.

- **Provide resources:**

Provide resources that support the development of life skills, such as articles, videos, and worksheets. This will help group members learn more about the skills they are developing and how they can apply them in real-life situations.

So, creating a collaborative environment to impart life skills requires a concerted effort to promote teamwork, communication, and mutual respect. With the right approach, you can help individuals develop the skills they need to succeed in life.

b. Benefits of collaborative learning

Collaborative learning refers to an educational approach that involves students working together in small groups to solve problems, complete assignments, [5] or learn new concepts. Here are some statistics related to collaborative learning:

- **Improved Academic Performance:** According to a study by the National Training Laboratories, students who learn collaboratively retain up to 90% of the material they learn compared to only 5% of those who learn through lecture.
- **Improved Critical Thinking Skills:** Collaborative learning helps students develop critical thinking skills as they learn from each other's perspectives and experiences.
- **Increased Student Engagement:** Collaborative learning increases student engagement by creating an active learning environment where students are motivated to participate and contribute.
- **Positive Impact on Social Skills:** Collaborative learning encourages students to communicate, listen, and interact with each other, which improves their social skills.
- **Better Retention of Information:** Collaborative learning improves retention of information as it creates a learning environment that is interactive, engaging, and fosters active participation.
- **Preparation for Real-world Situations:** Collaborative learning prepares students for real-world situations where they will have to work with others to achieve a common goal.
- **Increased Creativity:** Collaborative learning fosters creativity as students learn from each other and explore new ideas together.
- **Positive Impact on Motivation:** Collaborative learning positively impacts student motivation as students feel more responsible for their learning and are motivated to participate and contribute to group discussions.

- **Improved Problem-Solving Skills:** Collaborative learning improves problem-solving skills as students work together to identify, analyse, and solve problems.

Generally, collaborative learning has been shown to have a positive impact on academic performance, critical thinking skills, social skills, retention of information, creativity, motivation, and problem-solving skills.

c. Types of Learning groups in collaborative learning

There are several types of learning groups in collaborative learning that can be used to facilitate group learning and collaboration among learners[6]:

- **Base Groups:** A base group is a small group of learners who work together on a regular basis throughout the course or program. This type of group allows learners to build relationships, share knowledge and experiences, and support one another in their learning.
- **Task Groups:** A task group is formed for a specific task or project and disbands once the task is complete. This type of group allows learners to focus on a specific goal and develop skills such as communication, collaboration, and project management.
- **Interest Groups:** An interest group is formed around a shared interest or topic, allowing learners to explore their interests and passions. This type of group can help learners develop critical thinking skills, creativity, and problem-solving abilities.
- **Expert Groups:** Expert groups are formed based on learners' areas of expertise or knowledge. This type of group allows learners to share their knowledge and skills with others, and can promote peer teaching and learning.
- **Mixed Groups:** Mixed groups consist of learners with different backgrounds, experiences, and knowledge levels. This type of group promotes diversity and can help learners develop empathy, communication skills, and cross-cultural competence.

It is important to note that different types of learning groups can be combined or used in conjunction with each other to meet specific learning objectives or goals.

d. Methods to form learning groups

Forming learning groups in collaborative learning can be done in various ways, [7] including:

- **Random grouping:** Learners are randomly assigned to groups, with the aim of promoting diversity in terms of skills, knowledge, and experience. This method ensures that learners have an opportunity to interact with a diverse group of peers, which can promote collaboration and knowledge-sharing.
- **Self-selection:** Learners choose the group they wish to join based on their interests, skills, or background. This method can promote a sense of ownership and responsibility among learners, as they have chosen to work with their peers and are more likely to be invested in the group's success.

- **Teacher-assigned grouping:** The teacher or instructor assigns learners to groups based on their level of knowledge or skills. This method ensures that each group has a mix of learners with different levels of ability, and can also promote peer teaching and learning.
- **Interest-based grouping:** Learners are grouped based on their interests, which can lead to more focused and engaging discussions. This method can also encourage learners to explore new topics and perspectives.
- **Ability grouping:** Learners are grouped based on their abilities, with the aim of providing each group with a similar level of challenge. This method can be useful for learners who need more support or who are more advanced, but it can also lead to stigmatization or lack of motivation among learners who are placed in a lower group.

It is important to note that the method of forming learning groups in collaborative learning may depend on the learning objectives, the size of the class, and the preferences of the learners and the teacher or instructor.

e. Structuring roles in collaborative learning

Structuring roles in collaborative learning can help promote equal participation, clarify responsibilities, and ensure that each member of the group contributes to achieving the learning objectives. [7] Here are some roles that can be assigned to members of a collaborative learning group:

- **Facilitator:** The facilitator helps the group stay on task, manage time, and ensure that everyone has a chance to participate. They can also help resolve conflicts and keep the group focused on the learning goals.
- **Recorder:** The recorder takes notes during group discussions, synthesizes the ideas shared by group members, and communicates the group's progress to the rest of the class or instructor.
- **Researcher:** The researcher is responsible for gathering information and resources related to the group's topic or project. They can also help verify the accuracy and credibility of information.
- **Presenter:** The presenter is responsible for communicating the group's findings, ideas, or recommendations to the rest of the class or instructor. They can also help create visual aids or presentations to support their communication.
- **Timekeeper:** The timekeeper helps the group manage their time effectively and ensures that they stay on track to meet their goals.
- **Quality Control:** The quality control member is responsible for ensuring the group's work is of high quality, by checking for accuracy, completeness, and adherence to guidelines and instructions.
- **Encourager:** The encourager's role is to support and motivate group members, helping to build positive relationships within the group.

SKILL ENHANCEMENT IN COLLABORATIVE LEARNING: SIGNIFICANT SHIFT FROM TRADITIONAL
TEACHER-CENTERED APPROACH

It is important to note that roles can be assigned or rotated among group members to ensure that everyone has an opportunity to develop different skills and take on different responsibilities. Additionally, the roles assigned may depend on the nature of the learning task or project, and the learning objectives that the group is working towards.

2. Literature Survey

Collaborative learning has been found to be effective in enhancing skills among learners in various fields. Collaborative learning has been a popular topic in education research for the last 10 years. Here are some statistics and trends related to collaborative learning from the last decade:

TABLE 1: *Collaborative learning in skill enhancement*

Author	Description	Results & Findings
[8] Al-Ahdal et al. (2021)	The effectiveness of collaborative learning on enhancing nursing students' clinical skills.	Collaborative learning was effective in enhancing students' clinical skills, as it provided opportunities for learners to practice and receive feedback from their peers and instructors.
[9] Khojastehpour et al. (2014)	Collaborative learning was found to be effective in enhancing students' teamwork skills in a software engineering course.	Collaborative learning helped students develop interpersonal skills, such as communication, leadership, and conflict resolution, leading to improved teamwork abilities.
[10] Alkhannani (2021)	The effectiveness of collaborative learning on enhancing students' problem-solving skills in a science course.	Collaborative learning was effective in enhancing students' problem-solving skills, as it provided opportunities for learners to work together to solve complex problems, exchange ideas, and receive feedback.
[11] Wang et al. (2020)	Explored the impact of collaborative learning on enhancing students' creativity in a design course.	Collaborative learning significantly improved students' creativity, as it provided opportunities for learners to share ideas and perspectives, receive feedback, and engage in divergent thinking.
[12] Li et al. (2021)	Collaborative learning was found to be effective in enhancing students' problem-solving skills in a mathematics course.	The study found that collaborative learning provided opportunities for learners to share problem-solving strategies, receive feedback, and engage in meaningful discussions, leading to improved problem-solving abilities.
Liang et al. (2019)	The impact of collaborative learning on enhancing students' communication	Collaborative learning was effective in improving students' communication skills, as it provided opportunities for learners to

SKILL ENHANCEMENT IN COLLABORATIVE LEARNING: SIGNIFICANT SHIFT FROM TRADITIONAL
TEACHER-CENTERED APPROACH

	skills in a language learning context.	practice speaking, listening, and exchanging ideas with their peers.
[13] Su et al. (2018)	The effectiveness of collaborative learning on enhancing students' critical thinking skills in a physics course.	Collaborative learning significantly improved students' critical thinking skills, as it provided opportunities for learners to analyze and evaluate information, and engage in constructive discussions with their peers.
[14] Chen et al. (2018)	Investigated the effectiveness of collaborative learning on improving students' programming skills.	Collaborative learning significantly improved students' programming skills and their ability to work in teams.

According to a survey conducted by the National Survey of Student Engagement (NSSE), 80% of college students reported working in groups on assignments and projects in 2019. A study published in the journal *Educational Psychology Review* found that collaborative learning had a positive impact on students' academic achievement, motivation, and social skills. In a survey conducted by the Center for Digital Education, 75% of K-12 teachers reported using collaborative learning strategies in the classroom in 2019.

A meta-analysis of research [15] on collaborative learning found that it had a significant positive effect on student achievement across a range of subjects and grade levels. The use of online collaborative learning tools has increased in recent years, with platforms like Google Classroom and Edmodo gaining popularity among teachers and students. A study published in the *Journal of Educational Psychology* found that peer feedback and peer assessment were effective collaborative learning strategies that improved student performance and motivation. The COVID-19 pandemic forced many schools and universities to switch to online learning, leading to an increased focus on collaborative learning through virtual platforms.

Here are some studies that have explored the use of collaborative learning in skill enhancement in Table. Overall, these studies suggest that collaborative learning can be an effective approach for enhancing various skills among learners, including programming, communication, critical thinking, and problem-solving skills. Collaborative learning provides opportunities for learners to interact with their peers, share knowledge and expertise, and engage in constructive discussions, leading to deeper learning and skill enhancement.

3. Methodology

a. Spiral model for collaborative learning

The Spiral Model [16] is a popular approach to software development that is often used in collaborative learning. It involves the iterative development of software in small increments, with each iteration building on the previous one. Here are the main steps of the Spiral Model and how it can be applied to collaborative learning:

- **Planning:** In collaborative learning, the planning stage involves defining the learning objectives, identifying the students' needs and strengths, and establishing a clear plan

for the collaborative learning process. This can involve setting up group projects, defining the roles and responsibilities of each member, and identifying the resources and tools that will be used to support the learning process.

- **Risk Analysis:** Risk analysis involves identifying potential challenges and obstacles that may arise during the collaborative learning process. This can include challenges related to communication, time management, and conflicting priorities. In this stage, the group can also brainstorm solutions to these challenges and establish contingency plans if necessary.
- **Development:** In collaborative learning, the development stage involves implementing the plan and executing the collaborative learning process. This can involve working together on assignments, projects, or other learning activities, and actively engaging in group discussions and feedback.

Collaborative Knowledge improvement

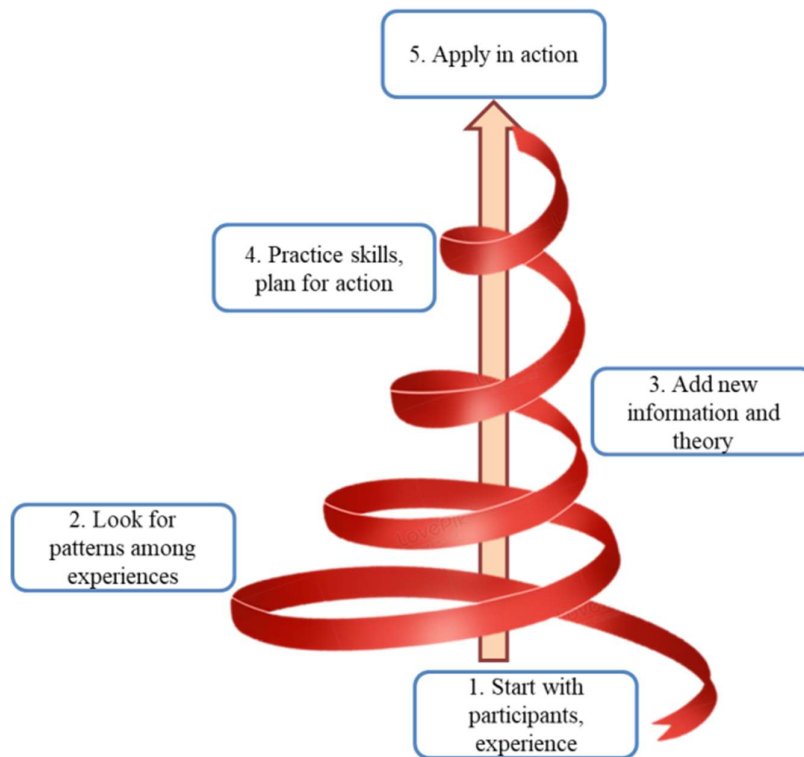


Figure (1): Spiral model for collaborative learning

- **Evaluation:** The evaluation stage involves assessing the effectiveness of the collaborative learning process and identifying areas for improvement. This can involve gathering feedback from each member of the group, analyzing the learning outcomes, and identifying any areas where the process could be improved.
- **Iteration:** Based on the evaluation, the group can then iterate the collaborative learning process, making adjustments and improvements as necessary. This can involve revising

the plan, refining the risk analysis, and making changes to the development process to better support the learning objectives.

The Spiral Model stresses the iterative evolution of the learning process [17] and allows for ongoing improvement based on feedback and evaluation, making it a useful approach to collaborative learning. Groups can establish a collaborative learning environment that is efficient, interesting, and supportive of their learning goals by working together to plan, identify potential risks and obstacles, devise solutions, evaluate results, and iterate the process.

b. SWOT ANALYSIS

SWOT analysis of skill enhancement in collaborative learning [18]:

Strengths:

- Collaborative learning has been shown to help students develop important skills such as communication, leadership, problem-solving, and conflict resolution.
- The use of peer assessment and feedback in collaborative learning can help students develop self-assessment skills and improve their ability to give and receive constructive feedback.
- Teachers can identify a range of skills that students develop through collaborative learning, including critical thinking, creativity, and the ability to work independently.
- Collaborative learning can improve students' social skills, including their ability to work effectively in groups and their willingness to seek and provide help.

Weaknesses:

- Some students may not be as comfortable working in groups, which can hinder their ability to develop collaborative skills.
- Students may have different learning styles or personalities that can lead to conflicts or difficulties in working together.
- Collaborative learning can be time-consuming and may require more preparation and planning than individual learning activities.
- It can be difficult to accurately assess individual students' contributions to group work, which can lead to disparities in grades and evaluation.

Opportunities:

- The use of online collaborative learning [19] tools can help students develop digital literacy skills and provide opportunities for collaboration outside of the classroom.
- Collaborative learning can be used to develop skills that are important for the workforce, such as teamwork and communication.
- There is an opportunity to develop new collaborative learning strategies and approaches that can improve student outcomes.
- The COVID-19 pandemic has highlighted the need for students to develop skills such as adaptability and resilience, which can be fostered through collaborative learning.

Threats:

SKILL ENHANCEMENT IN COLLABORATIVE LEARNING: SIGNIFICANT SHIFT FROM TRADITIONAL TEACHER-CENTERED APPROACH

- Some educators may not have the training or resources to effectively implement collaborative learning in the classroom.
- Collaborative learning can be challenging to manage and may require additional support from teachers or facilitators.
- Students may not always take collaborative learning seriously or may not be motivated to participate.
- The use of collaborative learning strategies may be seen as a departure from traditional teaching methods, which could lead to resistance or pushback from educators or administrators.

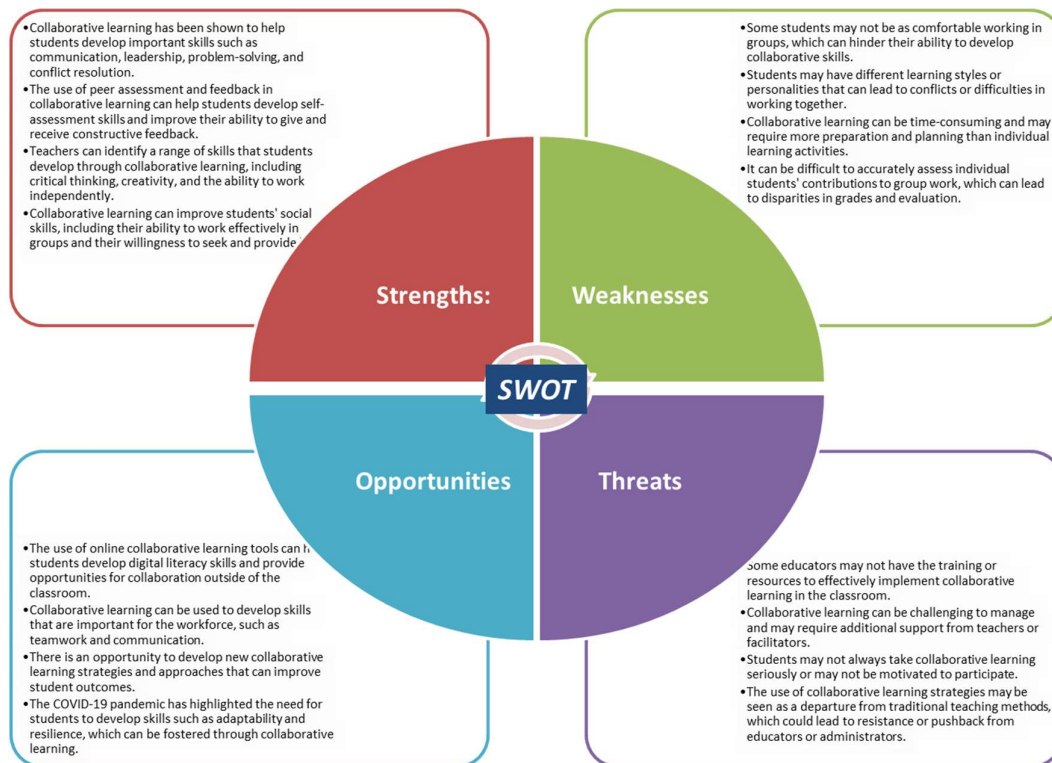


Figure (2): SWOT ANALYSIS

4. RESULTS AND DISCUSSION

A questionnaire [20] was created by the researchers to understand the students' perception of the evaluation process and their experience of working in a group (refer to Figures 3). The questionnaire included questions related to group behaviour and demographic information of the students. The survey instrument was reviewed for its suitability by colleagues who have expertise in conducting student surveys before its actual use.

SKILL ENHANCEMENT IN COLLABORATIVE LEARNING: SIGNIFICANT SHIFT FROM TRADITIONAL TEACHER-CENTERED APPROACH

Feedback on Collaborative Learning

* Required

- Email *
- Batch Number *
- Gender Set *
Mark only one oval.
 Only Girls
 Boys and Girls
 Only Boys
- Group Size *
Mark only one oval.
 Single
 Two Person Group
 Three Person Group
 Four Person Group
- Average CGPA of your Batch *
- How comfortable are you working in a group? *
Mark only one oval.
 Very comfortable
 Somewhat comfortable
 Neutral
 Somewhat uncomfortable
 Very uncomfortable
- What are your preferred methods of communication when working in a group? *
Mark only one oval.
 In-person meetings
 Online meetings
 Text messaging
 Email
 Other: _____
- How often do you communicate with your group members during a collaborative * project?
Mark only one oval.
 Daily
 Weekly
 Biweekly
 Monthly
 Other: _____
- What are your strengths when it comes to working in a group? *
Mark only one oval.
 Leadership
 Communication
 Problem-solving
- What are some challenges you have faced when working in a group? *
Mark only one oval.
 Conflicts with group members
 Difficulty coordinating schedules
 Lack of participation from group members
 Language barriers
- What do you think are the benefits of Project Groups? *
Mark only one oval.
 Learning from other perspectives
 Building teamwork skills
 Developing communication skills
 Expanding knowledge through shared resources
- What suggestions do you have for improving Project Group experiences? *
Mark only one oval.
 Providing clear guidelines and expectations for group projects
 Encouraging active participation from all group members
 Offering opportunities for peer feedback and evaluation
 Providing training on effective communication and conflict resolution

Figure (3): QUESTIONNAIRE FOR COLLABORATIVE LEARNING

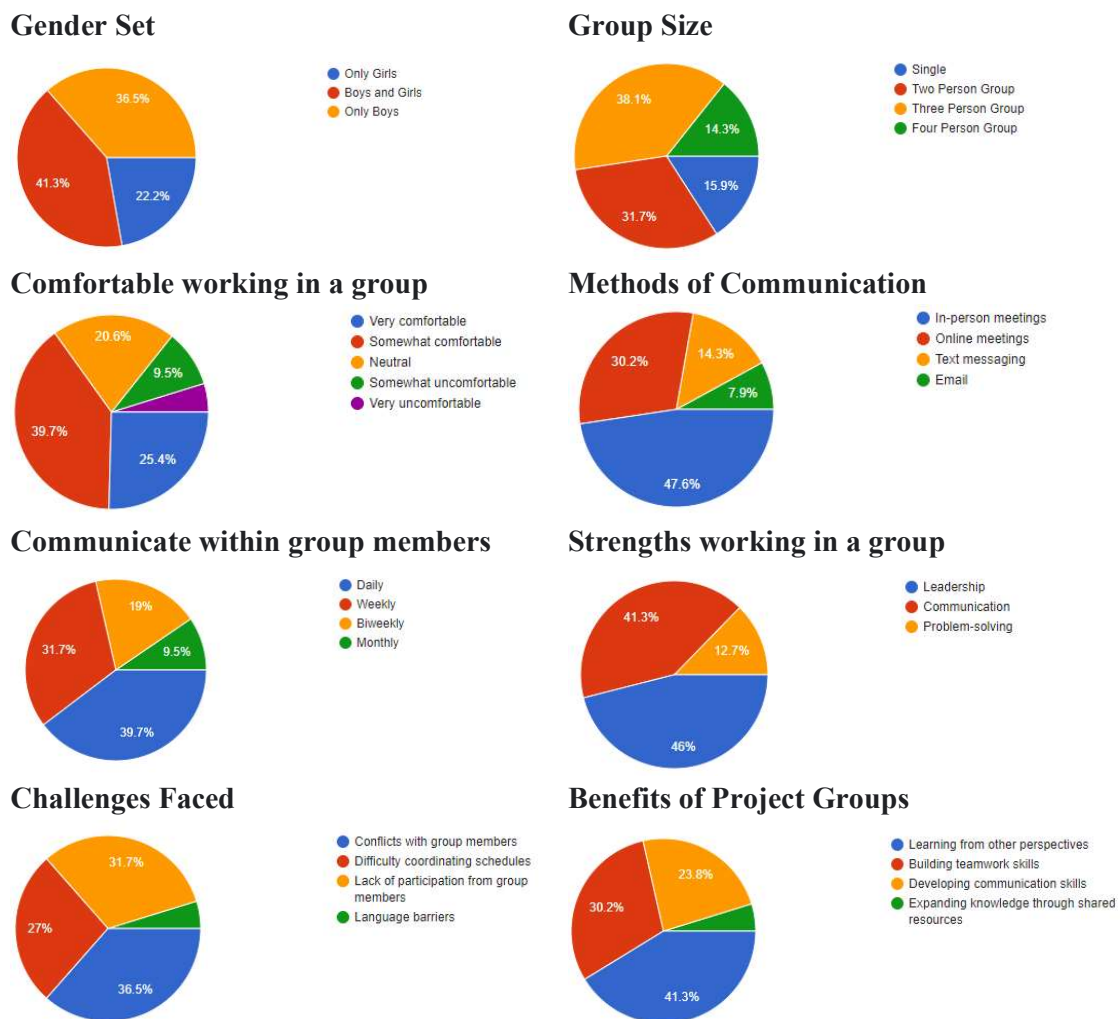


Figure (3): RESPONSE FROM THE QUESTIONNAIRE

There was no significant difference in the between responses in Gender set and Group size. Forty percent of the participants were Somewhat Comfortable working in a group. The remaining twenty-five percent reported Comfortable working in a group. Fifty percent of the participants were seniors; two-thirds were male. Forty Eight percent preferred in-person

meeting during communication within the group and Forty percent discussed about the projects in the daily basis whereas Thirty two preferred weekly discussions.

The average self-reported grade point average (GPA) was 8.79 on a 10-point scale, and analysis revealed that students with the highest GPAs opted to be placed in groups with other students with high GPAs. Forty Six percent of the participants indicated that Leadership motivated them to perform better, while 41% thought the Communication motivated their team members. Conflicts with group members contributed to 36.5% of challenges faced by the students whereas Difficulty coordinating schedules contributed 27%. Students were asked the benefits of Project Groups. Forty-one percent felt that it was learning from other perspectives. Three percent thought it built teamwork skills.

There are multiple constraints that affect the results. The sample only included students enrolled in one course from a single institution, which restricts the extent to which the findings can be applied to a broader population. The study's external validity may be limited as a result. Lastly, the incentive component of the grade assigned to the peer evaluation may not have been significant enough to encourage students to perform at the intended level.

5. Conclusion

In conclusion, collaborative learning can be an effective approach to skill enhancement, particularly in developing critical thinking, problem-solving, communication, teamwork, and leadership skills. However, it is important to consider the strengths, weaknesses, opportunities, and threats of collaborative learning when implementing it in an educational setting. Collaborative learning may not be suitable for all learners or all learning objectives, and instructors and educational institutions must provide the necessary support and resources for effective implementation. Overall, collaborative learning can be a valuable tool for skill enhancement and can prepare learners for real-world situations that require teamwork and collaboration.

References

- [1] Gillies, Robyn M., and Adrian F. Ashman. "The effects of cooperative learning on students with learning difficulties in the lower elementary school." *The Journal of Special Education* 34, no. 1 (2000): 19-27.
- [2] Molinillo, Sebastian, Rocío Aguilar-Illescas, Rafael Anaya-Sánchez, and María Vallespín-Arán. "Exploring the impacts of interactions, social presence and emotional engagement on active collaborative learning in a social web-based environment." *Computers & Education* 123 (2018): 41-52.
- [3] Saravanakumar, A. R. Life skill education through lifelong learning. Lulu. com, 2020.
- [4] Tursunovich, Rustamov Ilkhom. "Teaching a Foreign Language and Developing Language Competence." *Web of Scholars: Multidimensional Research Journal* 1, no. 8 (2022): 8-11.

- [5] Houghton, Deirdre, Gary Soles, Andrew Vogelsang, Valerie Irvine, Francois Prince, Leona Prince, Carla Martin, Jean-Paul Restoule, and Michael Paskevicius. "Truth and Reconciliation Through Inquiry-based Collaborative Learning." In *The Open/Technology in Education, Society, and Scholarship Association Conference*, vol. 2, no. 1, pp. 1-8. 2022.
- [6] Silva, Helena, José Lopes, Caroline Dominguez, and Eva Morais. "Lecture, Cooperative Learning and Concept Mapping: Any Differences on Critical and Creative Thinking Development?." *International Journal of Instruction* 15, no. 1 (2022): 765-780.
- [7] Uslu, Nilüfer Atman, and Hatice Yildiz Durak. "Predicting learner autonomy in collaborative learning: The role of group metacognition and motivational regulation strategies." *Learning and Motivation* 78 (2022): 101804.
- [8] Al-Ahdal, Arif Ahmed Mohammed Hassan, and Mohammed Abdullah Alharbi. "MALL in collaborative learning as a vocabulary-enhancing tool for EFL learners: A study across two Universities in Saudi Arabia." *Sage Open* 11, no. 1 (2021): 2158244021999062.
- [9] Khojastehpour, Morteza, and Raechel Johns. "Internationalization and relationship marketing: an introduction." *European Business Review* (2014).
- [10] Alkhannani, Badriah M. "The effectiveness of collaborative teaching and learning and engaging students as partners on English language teaching in Saudi Arabia." *Theory and Practice in Language Studies* 11, no. 10 (2021): 1288-1294.
- [11] Wang, Cixiao, Ting Fang, and Yinxuan Gu. "Learning performance and behavioral patterns of online collaborative learning: Impact of cognitive load and affordances of different multimedia." *Computers & Education* 143 (2020): 103683.
- [12] Li, Yi, Nora G. Kern, Simon L. Conti, and Lindsay A. Hampson. "Online collaborative learning in urology." *Current Urology Reports* 22, no. 12 (2021): 66.
- [13] Su, You, Yanyan Li, Jyh-Chong Liang, and Chin-Chung Tsai. "Moving literature circles into wiki-based environment: the role of online self-regulation in EFL learners' attitude toward collaborative learning." *Computer Assisted Language Learning* 32, no. 5-6 (2019): 556-586.
- [14] Chen, Clement, Keith T. Jones, and Shawn Xu. "The Association between Students' Style of Learning Preferences, Social Presence, Collaborative Learning and Learning Outcomes." *Journal of Educators Online* 15, no. 1 (2018): n1.
- [15] Jeong, Heisawn, Cindy E. Hmelo-Silver, and Kihyun Jo. "Ten years of computer-supported collaborative learning: A meta-analysis of CSCL in STEM education during 2005–2014." *Educational research review* 28 (2019): 100284.

- [16] Chen, Wenli, Jesmine SH Tan, and Zhongling Pi. "The spiral model of collaborative knowledge improvement: an exploratory study of a networked collaborative classroom." *International Journal of Computer-Supported Collaborative Learning* 16 (2021): 7-35.
- [17] Zaheer, M. Zaigham, Arif Mahmood, M. Haris Khan, Mattia Segu, Fisher Yu, and Seung-Ik Lee. "Generative cooperative learning for unsupervised video anomaly detection." In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pp. 14744-14754. 2022.
- [18] Hilal, Tariq Abu, and Hasan Abu Hilal. "Social Networking Applications: A Comparative Analysis for a Collaborative Learning through Google Classroom and Zoom." *Procedia Computer Science* 210 (2022): 61-69.
- [19] Perna, Johannes. "Possibilities and challenges of using educational cheminformatics for STEM education: A SWOT analysis of a molecular visualization engineering project." *Journal of Chemical Education* 99, no. 3 (2022): 1190-1200.
- [20] Chang, Yi-Hsing, Yin-Chen Yan, and You-Te Lu. "Effects of Combining Different Collaborative Learning Strategies with Problem-Based Learning in a Flipped Classroom on Program Language Learning." *Sustainability* 14, no. 9 (2022): 5282.