The paper was presented in the **11th International STEM Education Conference (iSTEM-Ed 2026)** by the 2nd author. The 1st author is thanked for Sponsoring the travel fund to present the paper.

Enhancing Collaborative Learning through Team-based Online Projects (TOP): A Post-Activity Analysis

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***Abstract*—COVID-19 made a major impact on the traditional educational patterns, and online learning forms were to be adopted at an extremely fast rate. Nevertheless, it was a significant challenge to maintain student engagement, collaboration, and effective learning outcomes online. The paper is the implementation and evaluation of the Team-based Online Projects (TOP) framework, which is a collaborative learning model aimed at recreating the advantages of face-to-face teamwork within an online environment. TOP model involves organized team building,/differentiated types of projects, consistent interaction, self-assessment, and peer evaluation as the means of enhancing active involvement and ability growth. A feedback questionnaire was completed by 93 respondents, and the outcomes showed that the participants had high levels of satisfaction in the main parameters, which include overall experience, engagement, skill development, and collaboration confidence. Two-factor ANOVA without replication reported the statistically significant differences among the participants and between the aspects of the survey ($p < 0.001$), therefore, showing the efficiency of the framework and the possible areas of improvement, especially in networking opportunities. The results prove that the TOP framework is a solid and scalable pedagogical model that allows facilitating collaborative learning, promoting professional growth, and can be successfully implemented in online and hybrid educational settings.**

Keywords—Team-based Online Projects, Collaborative Learning, Online Education, Active Learning, Peer Learning, Professional Development.

I. INTRODUCTION

The COVID-19 pandemic transformed the traditional form of education greatly, and institutions had to resort to the new means of preserving the continuity of academic processes across the globe [1-2]. Online education that initially began as a supplementary tool, quickly turned out to be the primary teaching tool. Still, the transition of face-to-face to online learning also showed that the process also has significant challenges, most notably, the challenges of maintaining the students on the task, fostering the cooperation, and ensuring the effective reception of knowledge. Team-based Online Projects (TOP) [3] in this view are a pedagogical approach that emerged to overcome these obstacles through facilitating active and collaborative learning in an online classroom. TOP is a concept suggested by Prof. S.K. Saha of IIT Delhi in an FDP at NIT Jamshedpur in June 2020. This programme was meant to mimic the advantages of face-to-face teamwork and project-based learning in a virtual environment. The strategy takes advantage of the benefits of collaborative learning, a teaching method that has been extensively known as effective at developing critical thinking, problem-solving abilities, and knowledge memory [4]. Research has also described team-based and collaborative learning to have a positive effect of improved academic outcomes, improvement of relations with others and psychological well-being among the team members [5-6].

In addition, the TOP framework is oriented towards the principles of active learning that are proved to increase the level of student engagement and contribute to the subsequent improvement of learning outcomes compared to the traditional lecture-based strategies [7]. Top achieves this by making the participants actively participate in frequent discussions, problem-solving, and peer assessment that allow the participants to be at the receiving end of information, and as such, they should be active participants of the learning process. The TOP model is also significant, and its effective application in other academic activities besides the first FDP supports the importance of the TOP model. As an illustration, Online Competitions conducted by Tezpur University using the TOP framework in conjunction with ReDySim-based Online Competitions through joint organizing in cooperation with IIT Delhi and IIT Jodhpur have been using the TOP framework, and have been met with approval and acceptance by those all over the world to enhance participants interaction and subsequent learning outcomes. These activities can be viewed as illustrations of the diversity of the TOP model and its ability to be modified to suit any type of discipline and

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learning environment. The TOP structure also addresses the requirements of the faculty members in the aspect of professional growth alongside academic studies.

In the era, when interdisciplinary cooperation becomes increasingly topical, TOP provides the members with the opportunities to meet other colleagues working in other institutions, exchange ideas, and develop relationships in research. This would be consistent with the overall goals of the faculty development programs which aim at enhancing the teaching and research capability of the teachers [8].

The influence of TOP on the professional development is especially strong considering the growing importance of collaborative research and the necessity of faculty to keep pace with the new developments. Research has indicated that faculty development programs that focus on collaboration and active learning result in a difference in the teaching practices and faculty satisfaction increase [9]. Incorporating these components into the paradigm of the TOP enables not merely to contribute to the immediate learning outcomes of the involved participants, but also perhaps impact their professional growth in the long run.

In the paper, the TOP framework and its implementation and effects on academic activities will be discussed. This study will be a review of the responses of participants in an attempt to point out the advantages of the TOP model and how it can work as a viable means of improving collaborative learning and professional growth in the post-pandemic educational environment.

II. Framework of TOP

The TOP model was well thought to replicate the interactive and collaborative environment of the traditional face-to-face group assignments within the online environment. TOP structure is oriented towards teamwork, regular interaction, peer and acquisition of practical skills which can be put into application in both academia and career setting. The subsequent paragraphs have divided the main points of the TOP framework into an elaborate list and defined its peculiarities and the rationale it has.

A. Formation of Teams

Formation of teams is the initial step in the TOP framework and teams are key to the success of the initiative. The participants will be separated into groups of 4-5 people, and the members of each group should preferably be members of different backgrounds and fields of expertise. This heterogeneity is not accidental because it has been found out that a heterogeneous team is more likely to offer more innovative solutions to problems because of diversity in perspectives and skills that the respective members offer. Every team has a team coordinator, who is very crucial in directing the activities of the group. The organizing committee usually picks the coordinator depending on his/her leadership qualities and experience to ensure that the team follows the schedule, addresses any conflicts and ensures that the communication between the team members is good.

B. Selection of Project Type

After having formed the teams in the second step, the selection of a project type is the next important step. The TOP framework offers the participants three different types of projects that are targeted at meeting three different interests and skills:

1) Literature Search (LS):

In this type of project, teams are required to conduct an in-depth review of existing literature on a specific topic. It is concentrated on the collection, analysis, and synthesis of information found on different sources to give a full picture of the topic. The given type of project is especially helpful when the participants wish to improve their research skills and increase their knowledge on a specific topic.

2) Algorithm Development (AD):

This category of project is where algorithms are created to solve a particular task like the kinematics analysis of a robot using software packages like RoboAnalyzer, Matlab, Octave, Freemat or Scilab. The teams can also decide to write algorithms in any programming language. The type of AD project is the best one to be engaged in by individuals who are deeply interested in coding, mathematics, and problem solving.

3) Design/Synthesis (DS):

In these types of projects, the teams are challenged to design or synthesize a new system or device to carry out a given task. As an illustration, a group may develop a mobile robot to be used in COVID-19 isolation units. This type of project promotes innovations, creativity, and it enables the participants to put their technical knowledge into practice.

The freedom of choice of the type of project is also available so that every participant can select a project that is more interesting to them and their expertise to achieve maximum engagement and learning outcomes.

C. Regular Meetings and Collaboration

One of the pillars of TOP framework is the mandate that the teams will hold frequent meetings during the project period. Teams are required to meet at least 30 minutes daily online or on the phone, but most of the teams have been having long durations together. These meetings serve multiple purposes:

1) Progress Monitoring:

Frequent meetings enable the teams to monitor their effectiveness in relation to the project schedule to ensure that the teams are on time and that is no problem is delayed.

2) Task Allocation:

Work/Task can be shared among the members of the team depending on individual strengths and expertise, and the workload is well distributed and efficiently.

3) Problem-Solving:

Team meetings offer a brainstorming and problem-solving session. The members will be in a position to share ideas and give feedback and collaborate in coming up with solutions thereby assuming a sense of ownership of the project.

4) Building Team Cohesion:

Members can gain trust and camaraderie because of continuous interaction, without which the collaboration process cannot be successful. The same meetings are also connected with social aspect that contributes to positive team dynamic which has been proven to enhance the performance of the team [10].

D. Presentation Preparation and Submission

The teams will be required to develop a presentation that will reflect on their work towards the end of the project. TOP framework has a very strict view of only six slides in a presentation and they should be submitted within a specific deadline in PDF format. The fact that the presentation is kept short is not by chance, since it requires the teams to generalize their findings and present them in an honest and succinct manner. The preparation of the presentation serves several important functions:

1) Summarization Skills:

Restricting the number of slides means teams will have to train the art of summing up complex information, which proves quite crucial in effective communication both in school and the workplace.

2) Clarity and Precision:

Limitation of the number of slides also makes teams are specific in their words and visual aid so that the main messages can be put across without wasting any information.

3) Team Collaboration:

The members of the team must collaborate towards the drafting of the presentation as they will need to discuss what they will incorporate in the presentation, how the slides would look and be designed. It is also an improvement in teamwork and decision-making.

E. Peer Review Process

The peer review process is one of the most innovative parts of the TOP framework. The other two/three teams need to evaluate the presentations made by each team. Such a peer evaluation process is a part of TOP framework due to the following reasons:

1) Critical Evaluation Skills:

The process of reviewing the work of peers demands the participants be critical with respect to the quality and rigor of the presented material. This is done to assist the participants in acquiring analytical skills and an appreciation of the evaluation criteria.

2) Exposure to Diverse Approaches:

The participants are exposed to different approaches, outlook and solutions when they view the presentation that is given by other teams. This not only expands their knowledge but also helps them in comparing themselves with their counterparts.

3) Feedback and Improvement:

The idea of feedback regarding peer reviews is excellent and provides the teams with adequate insight into the strong and weak sides of the work. This favourable critique is essential in the practice of lifelong enhancement and education.

F. Assessment and Reflection

The last aspect of the TOP framework is assessment and reflection. Teams are also given feedback on their presentations after the peer review process, which they are expected to consider. This reflection process is essential to strengthen the outcomes of learning and to define the directions of further development. It is also necessary to make the participants think about their team dynamics, personal contributions, and the experience they had in the TOP activity.

When the last presentation day comes, the team members should present their work before an expert panel. The TOP assessment process is formative and not a summative process, which is oriented on the development of skills and knowledge and not only on the giving of grades. This strategy is consistent with the latest educational concepts that imply the role of feedback and reflection in the learning process [11].

III. Benefits of TOP

The TOP model offers numerous benefits to both participants and organizers:

A. For Participants:

Networking: Participants get to know colleagues from different institutions and states, fostering potential future collaborations.

Teamwork: The activity enhances teamwork skills, enabling participants to work effectively with others and learn from shared experiences.

Professional Development: The process helps participants improve their presentation skills, gain confidence in their abilities, and identify areas for further development.

Peer Learning: Evaluating other teams' work offers insights into different approaches and methodologies, broadening participants' knowledge base.

B. For Organizers/Sponsors:

Enhanced Engagement: TOP encourages active participation, moving beyond traditional lecture-based learning.

Capacity Building: By engaging in the TOP process, faculty participants gain skills that can be replicated with their students, thereby addressing the issue of unemployability among graduates.

IV. Feedback collection and analysis

The online questionnaire comprising of 15 questions (including scaled-response, multiple-choice and open-ended questions) was used to collect feedback on 93 participants. The questionnaire was not directly adapted from an established standardised course evaluation instrument. The positive feedback of the TOP, in general, was very high as the satisfaction of the participants was high in a number of dimensions.

Most respondents (59.14%) rated their overall experience as being *Excellent* (4 points), and 37.63% of respondents rated

it as being *Good* (3 points). The percentage of lower ratings was very small. This has an average of about 3.5-3.6 out of 4, which means a high degree of satisfaction. Regarding organization and structure, 56.99% of the respondents rated it as *very well organized*, 39.78% as *well organized*, which made the mean score of about 3.5 out of 4. It implies that the TOP was *well-organized*, but there is still room to make slight changes that would increase the experience of participants. The level of engagement was also high with 52.69% considering the activities *Extremely engaging* and 38.71% considering the activities *Engaging*. The mean engagement score ranges around 3.4-3.5, which means that the activities were able to promote learning.

In terms of skill development, 58.06% of the participants said that they learned numerous *new skills*, and 36.56% said that they *improved a little*. The core skills developed were mostly communication, teamwork, problem-solving, and presentation skills and as a result of the TOP format being effective in promoting practical skills. The networking opportunities were met relatively differently. Although 59.14% were *very satisfied*, approximately 30.11% were "*Somewhat satisfied*", and a small percentage were limitedly satisfied.

The frequency of team meetings was diverse in the patterns of collaboration: 26.88% of the team meetings were daily, 35.48% of the team meetings were several times a week, and some attended weekly or even less. Such variation denotes variations in team dynamics, which might have affected the performance and satisfaction in general. The change in confidence of collaboration was very positive, and 63.44% indicated a significant change, and 27.96% indicated a moderate change. It leads to an average score of about 3.5-3.6, which points to the efficiency of TOP in developing collaborative confidence.

Knowledge exchange and peer learning were also rated highly, with 59.14% rating it as *Excellent* and 35.48 as *Good,* which gave an average score of approximately 3.5. A high majority (76.34%) said that they were ready to apply the TOP format in their practice or teaching, which proved its practicality and influence. Lastly, 67.74% of the participants were *very likely* to recommend the TOP to others, and 30.11% were likely, bringing an average score of around 3.6-3.7 out of 4, which is an overall approval rating of high quality.

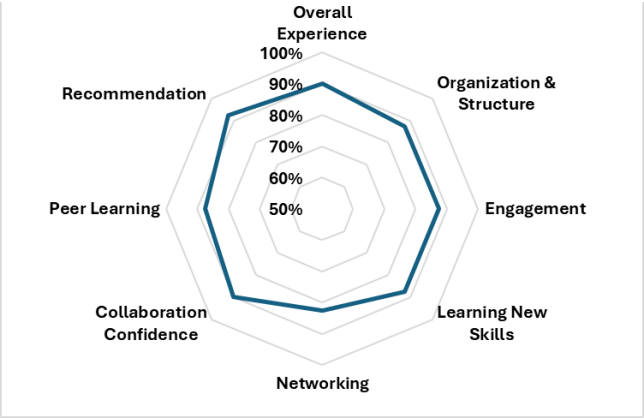


Fig. 1. .Spider Diagram Representing Participant Feedback on Various Aspects of TOP (In percentage).

The responses provided by the participants in the TOP show that people generally have a positive experience at many levels. The spider diagram in Figure 1 indicates the feedback of the participants on core areas. The greatest scores were recorded in recommendation (92.5%), overall experience (90%), and collaboration confidence (90%), which means that the participants are very satisfied and view the value of the collaboration as high. All the variables were rated consistently high (about 87.5%), which proves the efficiency of the TOP framework in enabling active and collaborative learning. The network opportunity was rated relatively lower (82.5%), which may be improved in promoting a better interaction between the participants. Altogether, the diagram is characterized by a good balance and a very positive perception of the participants regarding all the dimensions analyzed.

A two-factor ANOVA without replication [12] is used when there are two factors (in this case, subjects and survey questions), but each combination of these factors has only one observation (i.e., no repeated measures for each subject-question pair). In this analysis: Rows (Subjects) are the ones giving feedback. Columns (Survey Questions) are the points of the TOP under assessment. The lack of replication implies that we lack the multiple ratings of each pair of subjects-questions, but each participant provided a single rating on each question.

TABLE 1: TWO-FACTOR ANOVA WITHOUT REPLICATION FOR TEAM-BASED ONLINE PROJECTS (TOP) FEEDBACK

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	486.32	92	5.286	5.41	2.1E-28	1.29
Columns	82.47	9	9.163	9.38	3.4E-14	1.94
Error	808.56	828	0.976			
Total	1377.35	929				

*SS (Sum of Squares); df (Degrees of Freedom); MS (Mean Square);

A two-factor ANOVA without replication was conducted on the coded responses to the 10 scaled survey questions completed by 93 participants to examine overall variation across participant responses and survey dimensions. Since the survey responses were based on coded Likert-scale data, the ANOVA was used as an approximate exploratory parametric analysis. The analysis revealed significant variation across participant response patterns ($F(92,828)=5.41$; $p<0.001$) and across survey dimensions ($F(9,828)=9.38$; $p<0.001$), suggesting that certain aspects of the TOP framework were perceived more positively than others. The statistical findings are therefore presented as exploratory evidence consistent with the observed participant feedback trends rather than definitive proof of the effectiveness of the TOP framework.

The responses of participants in the TOP activity were overwhelming. The main insights and lessons that the participants will take are:

- Collaborative Learning: Participants appreciated the opportunity to work in teams, sharing ideas from different streams and benefiting from diverse perspectives.
- Professional Networking: The activity enabled participants to connect with researchers from other institutions, leading to potential joint publications and future collaborations.

- Skill Development: Participants reported improved communication skills, better understanding of teamwork, and enhanced research capabilities.
- Innovative Thinking: The team-based approach encouraged participants to innovate and bring forth new ideas for the betterment of society.

V. Conclusion:

The TOP model has proved to be a good and new method of improving online education through applying collaborative and active learning theories. The well-organized structure of TOP allowed to engage in meaningful interaction, develop the skills, and work with others more effectively, which is expressed in an extremely positive feedback provided by 93 respondents. The exploratory statistical analysis indicated significant variation across participant responses and across different aspects of the program, suggesting that some dimensions of the TOP framework were perceived more positively than others. Although some aspects, like networking, could be improved. In addition to the academic advantages, TOP also helped professionals to develop by promoting teamwork, communication, and interdisciplinary collaboration. Future studies can use better evaluation tools and other statistical methods to make the analysis more reliable.

Acknowledgment

The authors sincerely acknowledge the TOP participants and those who provided effective feedback.

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Appendix : Questionnaire

1. How would you rate your overall experience with the Team-based Online Projects (TOP)? Excellent (4 points); Good (3 points); Fair (2 points); Poor (1 point)

2. How did you find the organization and structure of the TOP? Very well organized (4 points); Well organized (3 points); Somewhat organized (2 points); Poorly organized (1 point)

3. How engaging did you find the TOP activities (e.g., did it help you to learn better)? Extremely engaging (4 points); Engaging (3 points); Somewhat engaging (2 points); Not engaging (1 point)

4. Have you learnt any new skill sets (e.g., how to present effectively and in a team?) Yes, many (4 points); Somewhat yes (3 points); Not much (1 points); Nothing (0 point)

5. How satisfied are you with the opportunity to network with peers during the TOP? Very satisfied (4 points); Somewhat satisfied (3 points); Not much satisfied (1 points); Could not spend time (0 point)

6. How frequently did your team meet to discuss the project? Daily (4 points); Several times a week (3 points); Weekly (2 points); Less than weekly (1 point)

7. How did the TOP impact your confidence in collaborating with others? Increased significantly (4 points); Increased somewhat (3 points); No change (0 point)

8. How well did the TOP format support peer learning and knowledge exchange? Excellent (4 points); Good (3 points); Fair (2 point); Poor (1 point).

9. Would you consider using the TOP format in your own teaching or professional practice? Yes (4 points); May be (2 points); No (0 point).

10. How likely are you to recommend participating in the TOP to colleagues or peers? Very likely (4 points); Likely (3 points); Neutral (1 point); Unlikely (0 point)

11. Did each team member contribute equally to the project? Yes; No.

12. How effectively did your team resolve conflicts or disagreements? Very effectively; Somewhat effectively; Not very effectively; Not at all.

13. What skills did you improve during the TOP (You may select more than one)? Teamwork; Communication; Problem-solving; Technical skills; Research skills; Presentation skills; No skill improvement;

14. What were the main benefits you gained from participating in the TOP (Select more than one)? Meeting new colleagues and networking with them; Learning new concepts and knowledge; Improving teamwork skills; Enhancing presentation skills; Collaborating on research; Planning for future collaborations; All the above

15. Any additional comments or feedback you would like to share about the TOP experience?

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