2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #33083

Work in Progress: Review of Teaching Strategies Towards Development of a Framework for Online Teamwork

Mr. Swapneel Thite P.E., University of New South Wales

Swapneel Thite is a PhD student of The University of New South Wales, Sydney. His work focusses specifically on improving Teamwork and Leadership skills in students to meet industry expectations. His passion for innovation in engineering education inspires his pursuit for knowledge.

Dr. Jayashri Ravishankar, University of New South Wales

Dr. Jayashri Ravishankar is currently the Associate Professor in the School of Electrical Engineering and Telecommunications, UNSW. Her research and teaching areas are in electrical power engineering. She is institutionally and internationally recognised for the impact of her innovative, research-led and highly effective teaching and leadership. Esteem indicators include Senior Fellowship of the Higher Education Academy awarded by Advance HE (UK) in 2018, Teaching Excellence Awards both from the Faculty of Engineering in 2016, UNSW-wide Teaching Excellence award in 2018 and the Australian National Award for University Teaching in 2019.

Dr. Araceli Martinez Ortiz, NASA Headquarters

Araceli Martinez Ortiz, PhD., is Research Associate Professor of Engineering Education in the College of Education at Texas State University. She leads a comprehensive research agenda related to issues of curriculum and instruction in engineering education, motivation and preparation of under served populations of students and teachers and in assessing the impact of operationalizing culturally responsive teaching in the STEM classroom. As executive director of the LBJ Institute for STEM Education and Research, she collaborates on various state and national STEM education programs and is PI on major grant initiatives through NASA MUREP and NSF Improving Undergraduate STEM Education and NSF DUE . Araceli holds Engineering degrees from The University of Michigan and Kettering University. She holds a Masters degree in Education from Michigan State and a PhD in Engineering Education from Tufts University.

Prof. Eliathamby Ambikairajah, University of New South Wales

Professor Eliathamby Ambikairajah received his BSc (Eng) (Hons) degree from the University of Sri Lanka, and received his PhD degree in Signal Processing from Keele University, UK. He was appointed as Head of Electronic Engineering and later Dean of Engineering at the Athlone Institute of Technology in the Republic of Ireland from 1982 to 1999. His key publications led to his repeated appointment as a short-term Invited Research Fellow with the British Telecom Laboratories, U.K., for ten years from 1989 to 1999.

Professor Ambikairajah served as the Acting Deputy Vice-Chancellor Enterprise during 2020, after previously serving as the Head of School of Electrical Engineering and Telecommunications, University of New South Wales (UNSW), Australia from 2009 to 2019.

His research interests include speaker and language recognition, emotion detection and biomedical signal processing. He has authored and co-authored approximately 300 journal and conference papers and is the recipient of many competitive research grants. He was a Faculty Associate with the Institute of Infocomm Research (A*STAR), Singapore from 2010 to 2018, and is currently an Advisory Board member of the AI Speech Lab at AI Singapore. Professor Ambikairajah was an Associate Editor for the IEEE Transactions on Education from 2012 to 2019.

He received the UNSW Vice-Chancellor's Award for Teaching Excellence in 2004 for his innovative use of educational technology and innovation in electrical engineering teaching programs, and in 2014 he received the UNSW Excellence in Senior Leadership Award. In 2019 was the recipient of the People's Choice Award as part of the UNSW President's Awards.

Professor Ambikairajah was an APSIPA Distinguished Lecturer for the 2013-14 term. He is a Fellow and a Chartered Engineer of the IET UK and Engineers Australia (EA) and is a Senior Member of the IEEE and a Life Member of APSIPA.

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Abstract:

Teamwork and leadership (T&L) skills are highly valued skills in industries all over the world. These graduate attributes significantly influence student employability and improve chances of early career growth. Coronavirus (COVID 19) pandemic has pushed the higher education sector to convert teaching delivery from face to face (f2f) to online abruptly. Teamwork activities are traditionally associated with f2f engagement between students, peers, and faculty. Hence, cultivating teamwork and leadership skills in an online environment where poor engagement and isolation are common problems need diligence in course design to resolve. The research question is "How to design an online course that leads to an improvement in teamwork and leadership skills of the students?" This review paper provides the blueprint for an "Online T&L framework" that assists in design of a course that utilizes T&L teaching pedagogies to improve T&L skills in students. The current version of the Online Teamwork and Leadership (OTL) framework is grounded in systematic literature review and critical analysis of the existing teamwork teaching methods, models and online learning theories like constructivism and cognitivism. It is built upon three major pillars: Community of Inquiry Framework, Tuckman's Model of Teamwork, and assessment methodologies. The idea is to simulate an industrial experience in a modular approach by introducing a structured weekly meeting to support the T&L pedagogy used and to accomplish this without sacrificing the technical content in the course. Furthermore, these modules include team building exercises along with a special leadership role that rotates weekly. A plan for implementation is discussed in this paper. Overall, the proposed OLT framework focusses on emulating an industrial teamwork environment in the university setting to add to student experience. It can be used by the wider academic community as a guide for designing engaging online courses comprising of teamwork and leadership skills as learning outcomes.

1. Introduction

Employability of graduates is a trivial question that has been focused upon in the field of engineering education for decades. There exists a gap between the skills possessed by graduates and the industrial requirement. This is often reflected in the form of lack of professional skills which involves teamwork and leadership skills [1].

The future of the industrial sector, represented by Industry 4.0 has specific requirements like teamwork and leadership (T&L) skills, self-regulated learning, and critical thinking, which needs to be satisfied by Education 4.0 [2]. T&L skills are highly rated and required skills in the industry [3]. The competencies defined in Engineers Australia stage 1 [4], consist of (i) knowledge and skill base (ii) engineering application ability, and (iii) professional and personal attributes. The first two are highly technical and form the theoretical basis of understanding for a young engineer. However, the third competency, i.e., professional and personal attribute which consists of "Effective team membership and team leadership" is where universities lack in meeting the requirements of the modern industry [5]. Grocutt [6], identified that Engineers Canada have individual and teamwork attributes as a requirement for accreditation. Subsequently, the survey conducted in the same paper found that students are aware of the importance of professional skills in their careers, hence requesting more training in the same. This highlighted the need to include teamwork training workshops as part of first year studies in engineering [6]. Furthermore, the accreditation board for engineering and technology (ABET), recognizes the significance of teamwork skills by adding this criteria for universities to ensure students possess the skills to operate in a high performing team [7].

The study by Qadir [8], talks about the top five skills required for electrical and computer science engineering graduates in the next decade which include teamwork and collaboration, communication skills, innovation, metacognition, and critical thinking. These were outlined based on the KSAVE framework designed by companies like Microsoft, Intel, and Cisco [8].

Hence, T&L skills play a key role in graduate attributes and future career progression of students and need to be integrated effectively into engineering courses.

The digital revolution has massively changed the way people learn. The universities need to adapt to these changes. COVID 19 has further pushed universities to adapt to a new way of teaching and learning. Existing face to face (f2f) courses need to transform to offer quality online education that achieves the learning outcomes [9].

This review paper has conducted analysis of online learning theories, existing frameworks, and teaching techniques to develop an online framework for course design that aims to improve students' T&L skills. A plan for implementation is also discussed in this paper.

The research question for this paper is "How to design an online course that leads to an improvement in Teamwork and Leadership skills in students".

2. Literature review

T&L Frameworks

A Conceptual framework is defined as a product of combining several related theories and concepts to predict, explain or give a better understanding of the topic of interest which could be called as a research problem [10]. In the education context, a framework for teamwork and leadership skills attempts to provide a guide to improve these skills in students. The systematic literature review conducted by Chowdhury found that there is no consensus among engineering education scholars on how to teach teamwork effectively and there is a gap in literature on effective teamwork models and frameworks [11]. Another review by Riebe found that curriculum design considerations to meet course learning outcomes are not understood at a deep level and require clarity [12]. With a rise in the use of online education after COVID-19, the need for an online framework addressing T&L skills has become increasingly important.

Adult literacy and life skills survey consisted of a teamwork framework which was created for the benefit of educators and employers to improve the teamwork skills of the employees and the general population. This theoretical model provides a general overview of the core team skills, competencies, and knowledge. It was not created for educators specifically and hence lacks the specific guidelines on team formation, assessment, and course design [13].

Endersby [14] in her work, developed a virtual leadership competency framework which includes aspects of team virtuality and how it differs from face-to-face aspects of a team. This theoretical framework focusses both on leadership and teamwork skills. However, this paper did not aim to provide guidelines for an online course design.

Chopade [15], in his work developed an interactive team collaborative and problem solving (ITCLP) framework for effective teamwork assessment. The ITCLP framework is a digital artificial intelligence (AI) tool for assessment, however, does not provide a guide for an online course design.

A framework for course design was prepared by Davis [16], which gives clear instructions on aspects of T&L to consider in course design, however it does not consider the need for simulating a virtual industrial environment to its delivery.

The frameworks mentioned above improve the understanding of T&L skills, provide tools to assess it and provide a guide for a f2f course design. However, a framework for online course design that targets T&L skills as a guide for educators needs to be created. An educational institution has a requirement to improve T&L skills in students to improve their employability. To achieve this a T&L framework for course design that induces an industrial work structure is extremely valuable for the students and needs to be developed.

The developed OLT framework in this paper aims to serve as a design guide for online courses teaching T&L skills with a focus on emulating an industrial teamwork experience for students.

Key attributes of T&L skills

To improve teamwork skills, it is necessary to understand key aspects of team development. One of the commonly used teamwork models in education space is Tuckman's Model of Team Development.

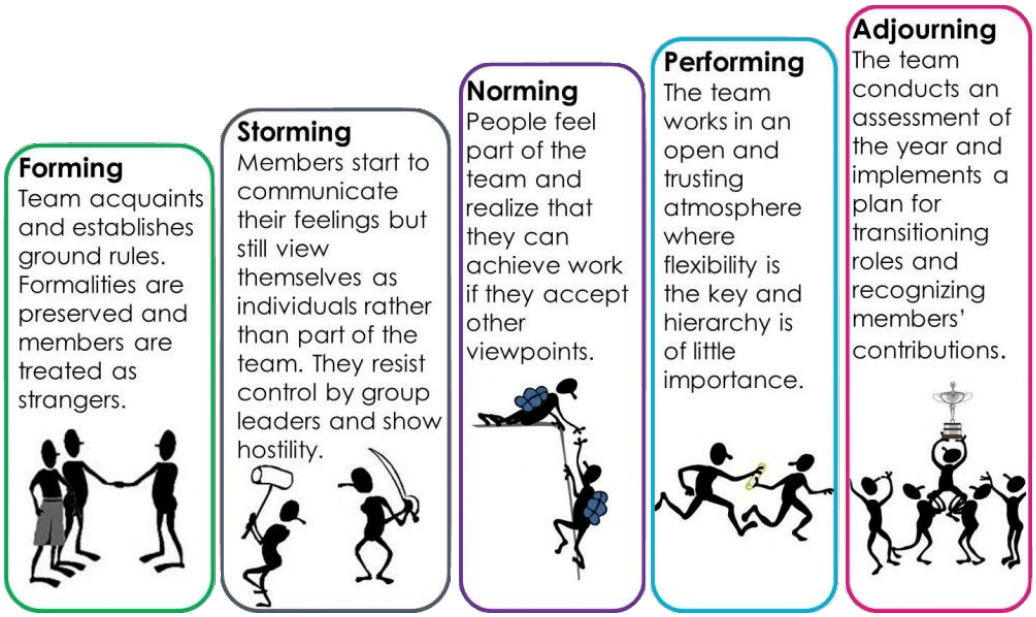

Figure 1 : Tuckman stages of team development [17]

It consists of six phases in the life cycle of a team called Forming, Storming, Norming, Performing and Adjourning as shown in figure 1 [17]. The forming stage is where members get introduced and develop opinions about each other. This stage ideally involves goal setting, icebreakers and team building activities. The storming stage consists of setting ground rules for the team, formulating plans and assigning roles and responsibilities. This stage ideally comes with conflicting opinions that needs to be addressed. Norming is where the relationships are built, and the group starts functioning as one unit displaying good teamwork skills. The performing stage is when the team it at its peak efficiency, trusting each other, displaying commitment and accountability for the common goal. The Adjourning stage is when members reflect on the team performance and provide peer evaluation at the close of a project [18].

Other team models that have been identified in literature include Cogs ladder model GPRI Model, and the Katzenbach and Smith Model [19] [20] [21] .While these models are an effective guide, Forsell [22], believes that theoretical models can vary based on circumstances and types

of teams and hence a more fluid approach to team modelling should be adopted. Various models could be utilized to suit specific type of teams [23].

Understanding the key attributes that makes teams successful is paramount. Chowdhury [11], did a systematic literature review on the T&L attributes and compiled a list of the most important which are described below:

1. ***Shared Goal and Value*** – A sense of common goal promotes unity and cohesiveness.
2. ***Commitment to Team Success*** – Every member must possess a strong passion for the team to succeed.
3. ***Motivation*** – Positive team perception promotes motivation which keeps members satisfied and engaged. Recognizing individual contributions without expectations is the key to high motivation with the team.
4. ***Interpersonal Skills*** –Team relations external to workplace is important in building trust and care for each other. This develops the interpersonal aspect with the team.
5. ***Open Effective Communication*** – Expressing feelings and actively listening encourages open dialogue and communication which is essential for team effectiveness.
6. ***Constructive Feedback*** – Culture of constructive criticism where members accept the feedback in a non-protective and positive way is important.
7. ***Ideal Team Composition*** – The members in the team should have knowledge of the topic, share top ideas and decisions should be taken with consensus rather than disagreements.
8. ***Leadership*** – The most influential attribute towards team success. A leader must be appointed with consensus who can assign and explain roles, give timelines for completion, monitor progress, provide resources, and most importantly listen to every member idea attentively.
9. ***Accountability*** – Members should take responsibility of assigned tasks and ensure they are done properly and within the deadline. The members should also be able to explain reasoning for the steps taken to complete the task.
10. ***Interdependence*** – Supporting and helping each other while promoting individual contribution creates a sense of interdependence.
11. ***Adherence to Team Process and Performance*** – Decision making, and solutions proposed must be feasible and beneficial for the team. Observing best practices from other high performing teams can help team processes.

The OLT framework should ensure these key attributes are addressed in their team building exercises.

Online Learning Theories

Understanding how people learn forms the basis for selection of teaching methodologies and provides insights into how effective these will become. The selection of these theories is based on the learning outcomes of the specific course. Teaching methods selected and designed on fundamentals of learning theories are considered reliable and verified. Learning theories are broadly categorized into Behaviorism, Cognitivism and Constructivism [24].

Considerations need to be made about the targeted learning outcomes and challenges of online learning while researching suitable theories. The online learning theories that suit teamwork and leadership skills are broadly Constructivism and Cognitivism [25], [26].

Constructivism is a student centric theory where students take an active role while teachers play supporting role. It focusses on constructing new knowledge based on prior knowledge via collaboration with peers. This theory represents teamwork and leadership skills [27].

Cognitivism identifies that learning is an internal process and involves thinking, motivation, memory, and reflection. However, this theory requires teachers to take a leading role. This theory is highly suitable for online instruction as it often involves learning via visual and audible sources like videos, images, text, and graphical user interfaces. The Cognitive Load Theory states that this information needs to be structured and broken into small chunks to retain the information in the learner's long-term memory [28]. Cognitivism also claims to create original thoughts based on prior knowledge. This theory clearly represents the modern online course structure [29]. It is therefore important to take this into consideration while building the course online.

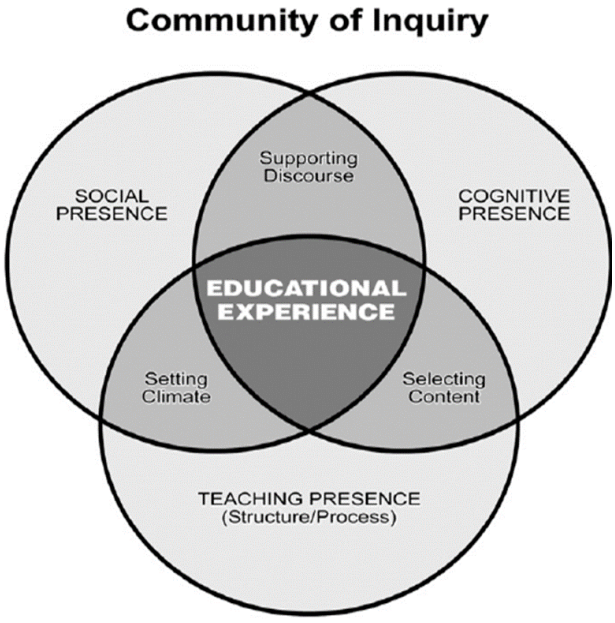

Figure 2: Community of Inquiry Framework [30]

Community of inquiry framework (COI) is an effective online model based on the constructivist theory. Garrison, Archer and Walter [30] created this framework which focusses on creating a meaningful learning experience. Three founding dimensions of this theory are cognitive, social and teaching presence as shown in figure 2. The capacity of an educational environment to construct meaning via sustained communication signifies cognitive presence. Capacity of learners to project their personal attributes into the teaching framework signifies social presence. Teacher presence is signified via two functions: (i) Course planning including design of learning activities, assessment and preparing resources for students; and (ii) Accountability for teaching with or without the help of teaching assistants [31]. This framework was verified to have a reliable structure by Heilporn [32], who found high consistency in the three main dimensions discussed above. Online courses with teamwork components need to adhere to the COI framework and the cognitive overload theory to get the best learning outcomes.

T&L Teaching Strategies

There exist teamwork teaching methods that either have foreground focus on teaching professional skills or core engineering concepts. The latter, is often a mixture of core learning outcomes and team activities [33]. Some popular active learning approaches that aim to indirectly teach teamwork skills include Project Based Learning (PBL), Problem Based Learning (PML), Team Based Learning (TBL), and Gamification [34]. TBL is based on the constructivist learning model which enhances teamwork and collaboration while solving complex problems [35]. PBL is a more popular inquiry-based teaching method in engineering education. It is also based on the constructivist learning theory where students play an active role and construct knowledge via shared experiences. Projects given to students relate to a real-world application. Milestones setting and formative assessment play a key role in PBL and the focus is on the learning process rather than final outcome [36]. PML has its origins in medical education and was slowly adapted into engineering education. An ill structured problem is provided which potentially has several solutions. Students take ownership of the learning process, find relevant knowledge and use it to come up with variety of solutions [37]. Gamification is on the rise in the field of engineering education in the last decade [38]. It is based on a behaviorist theoretical approach which depends on learner's response to stimuli, positive or negative reinforcement and extrinsic motivation. Motivational factors involved in games are used to enhance engagement and learning outcomes of the student in a competitive environment [39]. Use of leaderboards, badges and points are common tools used in this method [40]. There are direct teamwork teaching approaches which include experiential learning, workshop, and short professional development courses. These are ideally implemented exclusive of the core engineering learning activities. However, striking a balance between inclusion of professional and technical skills leads to desirable outcomes [33].

From the above literature, a common theme observed was that (i) T&L skills are often a by-product of the main learning activity and (ii) The experiential aspect of leadership is missing from these activities. Introducing students to the key aspects of T&L skills while maintaining the core components of the above teaching pedagogies is important while designing the online T&L framework.

3. Modular Framework for online T&L skills

Every course has its own requirements, learning outcomes, availability of resources and flexibility. Therefore, it is not feasible to design a teaching method that suits all course types. Instead, a framework that fits to conditions and provides flexibility to its implementation is needed. Indirect teamwork teaching approaches like PBL, TBL and PML have focus on the project outcomes. Consequently, students learn the teamwork concepts by trial and error. Student's default to dividing the project into smaller tasks and finish the project as an individual assignment, combining individual parts before submission [41]. Direct teamwork teaching approaches like workshops, short courses, and experiential learning focus on developing the professional skills which require extra time to prepare and need increased resources depending on size of the course [42].

Therefore, having a framework that strikes a balance in teaching core engineering concepts and professional skills is a key to achieving the best outcome [16].

Development of the Online T&L Framework (OTLF)

The OLT framework proposed in this study is based on the combined fundamentals of Tuckman's model of teamwork which was summarized in Riebe's work [12], community of inquiry framework which is based upon the constructivist learning theory [31], cognitive overload theory [28] and the conceptual teamwork model by Davis [16].

The core idea behind this framework is to emulate an industrial environment by formalizing the learning activity to include weekly meetings for teams and their teaching team to plan the project in a systematic manner. Introducing organizational activities like assignment of roles and weekly milestones increases work efficiency and keeps the students engaged. The leader assumes the role of a manager who takes charge and provides motivation and ensures task completion. This should be established while building a community where asking questions and constructive discussions are encouraged. Staggers [18], in her work, identified team building is another key component essential to forming high performing teams. Hence, it is important that the T&L concepts introduced are realized by students within the team building exercises.

Lydia [51] has gathered some common methods to team formation which are listed below:

- ***Random*** – Spreadsheet is used with student information which is sorted by a specific criterion like identity number.
- ***Student choice*** – Create group numbers and students choose which group they want to join themselves.
- ***Aspirational*** – Survey students to find out the grades they wish to achieve in the course and sort the students with similar aspirations in the same group.
- ***Availability*** – Survey to ask students their preferred meeting time and location. Students with the same availability and location can be grouped together.
- ***Previous achievement*** – Group students based on their cumulative marks or percentage.
- ***Different projects, skills and knowledge*** – Conduct a survey to ask students their strengths and skills. Group students to incorporate various skillsets in one team.

One of the above should be used to form the teams based on the number of enrollments, learning outcomes and other circumstances specific to the course.

Critical resources required in adoption of this framework are:

- ***Team based core engineering learning activity****:*

  There needs to be a core engineering teaching pedagogy to be able to maintain the balance with the introduction of the T&L skill concepts [16].

- ***Teaching assistants (TAs)***

  TAs are critical for a team based model to be successful [43]. TAs should be assigned to specific groups to look after to track the students' performance effectively. They perform the task of marking the students' discussions and providing regular weekly feedback.

- ***TA training on Teamwork Concepts***

  It is essential for the TAs to go through a short training themselves to be able to convey those concepts to students [44]. This training can be a short course on T&L skills that is taught in the university or can be approached online externally. One of the examples is MIT edx which has a course on "Working in teams: A practical guide" This training encompasses the basic teamwork concepts required to be delivered to students [45].

- ***Weekly TA meetings***

  TAs in the course need to meet and ensure that fidelity is maintained in course delivery and marking. This requires regular TA meetings [44].

- ***Teams of maximum five students***

  Quality of learning is affected by the team size. Bigger teams ideally result in lower quality of learning. It is therefore necessary to limit this number to maximum five students [46]

- ***Learning Management Systems (LMS)***

  Online platforms and LMS need to provide content containing videos, images and text that are designed to avoid cognitive overload. Selection of appropriate learning platform is a key to successful collaborative sessions [28].

- ***Networking platforms***

  The networking platforms play an integral part in enabling the class and the teams to build an efficient vibrant community of inquiry. They need to be powerful enough to support the large class size [47]

- ***Weekly Team meeting***

  The regular team meetings including the students and designated TAs as silent observers is the most important aspect to simulate a structured industrial emulation.

Other than the above items a community of inquiry, assessment method, leadership role and modular structure as described below should be established:

1) Community of Inquiry Implementation

The online platforms should adhere to the below requirements to establish a COI model in the course [31]:

- Highlight the importance of the T&L components and provide the marking rubric in the first week.
- Create private team channels to promote efficient collaboration within the teams.
- Create a discussion forum for the whole class. Brainstorming and interactions in these forums can be triggered by the TAs if required.
- Have an anonymous peer feedback system set up for every week.
- TAs to provide marks and feedback weekly to the individuals and the whole team.

2) Assessment Methodology

The existing assessment methodology for marking the main teaching pedagogy like PBL or PML can be maintained. This final submission mark in the applied pedagogy can be individualized based on their T&L skills. To do this, a rubric created based on American association of colleges and universities called "VALUE" can be used [48], [49]. This rubric has six criteria and four levels that are used to individualize the overall student marks based on their weekly contribution. The six teamwork elements (criteria) assessed are as follows: (i) Fosters constructive team climate, (ii) Contribution to team meetings, (iii) Facilitates the contribution of team members, (iv) Individual contributions outside of team meeting, (v) Adaptability and negotiation, and (vi) Responds to conflict. The four levels in each criterion are defined thoroughly to help in marking. This assessment methodology considers the key attributes of T&L discussed earlier. This kind of assessment requires TAs to monitor student discussions on a weekly basis.

3) Leadership Role

Leadership is one of the most essential attributes of teamwork and is a standalone skill. The traditional leadership methods need to adapt to the virtual environment in the 21st century called e-leadership. Transformational leadership style requires leaders to inspire followers to work whereas Transaction leadership style clearly identifies roles, motivates the team and reinforces the vision [50]. These styles need to be present in the upcoming virtual leaders. All students should develop this skill hence leaders should be assigned for every week to ensures that everyone gets an opportunity to lead the team. Based on the type of the activity, other roles in the team also need to be assigned at the concept stage. The leadership roles and responsibilities in general are as follows:

- Checking the progress of the team members
- Checking if the project is on track.
- Coordinating solutions to challenges faced.
- Encouraging team members to achieve and push for milestones.
- Holding members accountable for their roles.
- Formulating milestones for the following week.
- Submitting the formulated milestones in the meeting on the private team's channel.

4) Modular Structure

The weekly modules need to be structured as below [16]:

- Introduction to the weekly Teamwork Concept
- Reflection activity on personal experiences about the teamwork concept.
- Team building exercise based on the modular teamwork topic.
- Team discussions on the core teaching pedagogy. Leaders to check previous milestones and set new milestones for the upcoming week.

Teamwork concepts for weekly modules derived from literature that should be covered in the modular meetings were identified to be Concept Plan and Assigning Roles, Communication Skills, Leadership Skills, Accountability and Trust, Conflict Management, Reflection and Feedback [51], [42], [52].

Based on the above, the modules in the developed framework are shown in Table 1 [12]:

Table 1: Modular Teamwork Structure [12]

Module	**Teamwork Concept**	**Activities and Expected behavior**
1	Concept Plan and Role Assignment	Team Introductions, Goal Setting, and Ice breaking activities (Forming)
2	Communication Skills	Assign roles and responsibilities with rotating leadership roles, set time for regular meetings, prepare concept map (Storming)
3	Conflict Management	Introduce Ruble and Thomas approach to conflict management [53]. (storming)
4	Leadership Skills	Student begins to function as a cohesive team and display critical teamwork skills (Norming)
5	Accountability and Trust	Mutual Trust is established; members display commitment and TAs take a passive role (Performing)
6	Reflection and Feedback	Teams reflect on their achievements; complete peer marking and discuss the takeaway points (Adjourning)

4. Plan for Implementation

This framework's first trial was run in 2020. The trial had positive feedback from the students and the TAs. Some lessons learnt were that the roles assigned to the students should be kept flexible so that students can add new roles if necessary, There is an intention to run this framework at least three times in this course to procure enough data to prove its validity. The general outline of the second implementation is discussed below:

- Teams will be divided in a group of five students. TAs will be allocated to specific teams.
- TAs will undertake a short training course on teamwork and leadership prior to the course.
- Creation of private Microsoft Teams groups to provide the teams a platform for interaction. Discussions and collaborations between teams will be highly encouraged to build a community of inquiry.
- Weekly Teamwork Structure:
    - Team Meeting with the TA – Forty-Five minutes per week (Marked for Discussions)
    - Internal Team Meeting – One hour per week (In absence of the TA)

The forty-five minutes per week with the TA will have an instruction leaflet which will follow the structure of introducing the teamwork concept, reflection activity, team building exercise and project discussion. The roles assigned will be rotated and will include a leadership role which will be rotated every week to ensure everyone gets that experience. The leader in discussion with the team will review and add milestones to each team member including themselves for the following week.

The VALUE rubric [48] will be used by TAs to assess the students' teamwork capabilities. TAs would also be responsible to provide regular feedback to students every week.

The teamwork modules will be introduced for the first eight weeks in this course comprising of Introductions and Overview, Concept Plan and Role Assignments, Leadership, Communication, Accountability and Trust, Conflict Management, and Application of Teamwork and Reflections.

All three iterations of implementation will provide enough data to make valid conclusions on the success of this framework.

5. Discussion and Analysis

The Online Teamwork and Leadership Framework (OLTF) developed in this study has provided a blueprint for a structured modular approach to developing T&L skills in students. The review identifies the need for balancing the teaching of core engineering aspects along with T&L concepts. The proposition behind this implementation was to emulate an industrial team teamwork environment. OLTF incorporates an important leadership role to develop leadership attributes within the students which are overlooked in a traditional teamwork teaching pedagogy. Some important OLTF design requirements involve building a community of inquiry and utilizing a rubric for assessment.

Some limitations for the implementation could be availability of TAs, training for TAs, and incorporating weekly modular meetings which may be difficult in some course with tight structures and limited resources.

Further research is required to investigate aspects of developing a more generalized framework that considers course requirements, learning outcomes and resources as inputs and provides a blueprint for implementing teamwork modules suitable to a specific course. Another avenue to explore would be to see the differences within the face to face and online students to build a hybrid model in the future. Additionally, there is scope for further research in developing a marking rubric that could allow for peer marking, that could be adopted for large courses without the need to engage too many TAs.

6. Conclusion

The need for a structured framework in online courses to develop T&L skills in students in an industrial context is presented. This paper reviewed existing T&L frameworks, key attributes of T&L skills, online learning theories and existing T&L teaching pedagogies to develop an online T&L framework that aims to emulate an industrial team environment to better prepare fresh graduates. The blueprint provided in this framework can be beneficial to the academic community to design courses that have sufficient flexibility and resources to incorporate the modular structure to develop T&L skills in students.

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