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Blended Learning Tools and Practices: A Comprehensive Survey

Adarsh Kumar[1], Rajalakshmi Krishnamurthi[2], Surabhi Bhatia[3], Keshav Kaushik[1], Neelu Jyoti Ahuja[1], Anand Nayyar[4,5], Mehedi Masud[6]

[1]School of Computer Sciences, University of Petroleum and Energy Studies, Dehradun, India
[2]Department of Computer Science and Engineering, Jaypee Institute of Information Technology, Noida, India
[3]Department of Information Systems, College of Computer science and information technology, King Faisal University, Hofuf, Saudi Arabia
[4]Graduate School, Duy Tan University, Da Nang 550000, Vietnam
[5]Faculty of Information Technology, Duy Tan University, Da Nang 550000, Vietnam
[6]Department of Computer Science, College of Computers and Information Technology, Taif University, Taif, 21944, Saudi Arabia

Corresponding author: Adarsh Kumar (e-mail: adarsh.kumar@ddn.upes.ac.in), Anand Nayyar (e-mail: anandnayyar@duytan.edu.vn)

ABSTRACT Blended learning incorporates online learning experiences and helps students for meaningful learning through flexible online information and communication technologies, reduced overcrowded classroom presence, and planned teaching and learning experience. This study has conducted surveys of various tools, techniques, frameworks, and models useful for blended learning. This article has prepared a comprehensive survey of student, teacher, and management experiences in blended learning courses during COVID-19 and pre-COVID-19 times. The survey will be useful to faculty members, students, and management to adopt new tools and mindsets for positive outcomes. This work reports on implementing and assessing blended learning at two different universities (University of Petroleum and Energy Studies, India, and Jaypee Institute of Information Technology, Noida, India). The assessments prepare the benefits and challenges of learning (by students) and teaching (by faculty) blended learning courses with different online learning tools. Additionally, student performance in the traditional and blended learning courses was compared to list the concerns about effectively shifting the face-to-face courses to a blended learning model in emergencies like COVID-19. As a result, it has been observed that blended learning is helpful for school, university, and professional training. A large set of online and e-learning platforms are developed in recent times that can be used in blended learning to improve the learner's abilities. The use of similar tools (Blackboard, CodeTantra, and g suite) has fulfilled the requirements of the two universities, and timely conducted and completed all academic activities during pandemic times.

INDEX TERMS Active Learning, Blended Learning, COVID-19, E-Learning, Learning Tools, Online Learning, Pandemic.

I. INTRODUCTION

Blended learning is hybrid of traditional face-to-face classroom and e-learning experiences. This type of learning is getting popular in many worldwide renowned universities for improving learning standards, increasing passing rates of examinations, adding time flexibility, and removing distance barriers [1]-[3]. The multi-delivery approach to optimize learning outcomes and the cost of content delivery makes blended learning more useful. The term 'blend' in blended learning means integration of digital contents and/or in-class instructions and activities. Blended learning is an intermediate stage between in-classroom instructions and delivery of the contents in a fully online mode. Thus, blended learning is a type of digital integration in teaching. Blended learning is different from online learning which is another type of digital teaching. Blended learning is executed in pre-planned chained or combination models. Whereas, online learning is executed in either on-campus or off-campus models. Blending of a course gives more course content accessibility, pedagogical effectiveness, effective course interactions, and flexibility to teachers for better student engagement. There is no standard way of blending autonomous online learning, synchronous or asynchronous online learning, and traditional face-to-face instructions-based classroom learning approach. However, a well-planned pedagogical model is useful and important that prepares acyclical and coherent learning practice, for the students, developed by a trained faculty. In past, various surveys have been prepared to identify the importance of Blended learning practices in various disciplines. Some of these surveys and their important findings are briefly described as follows.

- Barbour et al. [4] surveyed Blended learning policies and procedures followed in different geographical regions. This is a detailed statistical survey over Online and Blended learning for K-12 schools around the world. It has been observed that lack of government policies and clarity in goals over online learning practices are major hindrances in adopting such learning practices. This survey has prepared in-depth parameters that are the major hurdles in implementing Online and Blended learning programs in different regions. Further, a detailed country-wise profile for learning programs is prepared. This profile provides information about private and publication partners, funding sources, challenges, current status, student information, teachers' training programs, and other summarised information over Online and Blended learning programs.
- In [5], a survey over mobile learning approaches for teaching the Internet of Things (IoT) is discussed. In this survey, the major mobile learning approaches, contributions, challenges, learnings, and suitability to an environment are discussed for teaching IoT courses. In observations, it has been found that rapidly developing online, web and mobile-based applications and tools are making the IoT course content teaching much convenient and easy compared to earlier practices of teaching software engineering.
- Kirillova et al. [6] surveyed different Blended learning models, their importance, and brief comparative analysis. In observation, it has been found that project-based blended learning (PBL) is more effective compared to other learning models for foreign language-based communication issues in learning. Using PBL, students can be engaged in those activities that they found more interesting in their learning and career. However, other Blended learning models are also found to be important in different studies implemented at different places.
- Siah et al. [7] examine the need for Blended learning pedagogy in a clinical skill program using the Community of Inquiry (CoI) framework. This study was also conducted to improve the nursing student's knowledge and satisfaction. This shows that there is wide adaptability of Blended learning programs in cross-disciplines. In observations, it has been found that Blended learning approaches are helpful to save time in the health science domain especially for those experts that are experienced and provide good quality education. This study uses quasi-experimental and pretest-posttest design over the clinical-based module to 1st year nursing students. Results show that the proposed Blended learning practices improve the student's performance and cognitive and social presence. However, moderate-level student satisfaction is found. Further, it has been observed that there is a need to identify the factors and strategies that could improve student satisfaction.
- Wu et al. [8] discussed similar practices for nursing students in the patient care environment. In these practices, it has been observed that clinical competencies and professionalism play important role in problem-solving and critical thinking. The clinical competencies-based on problem-solving and critical thinking can be improved using Blended learning. Here, a clinical teaching blended learning (CTBL) program is designed using web-based clinical pedagogy and case-based learning for improving competencies, self-efficacies, and other parameters like blended learning outcomes. CTBL program practices over 150 nurses with the web-based platform and other competencies show that blended learning is an effective approach for improving clinical student's performances.
- Ożadowicz [9] described the importance of blended learning during COVID-19 times which every student has realized and practiced in recent learnings. This work has survey the importance of the blended learning approach by modifying the blended learning method in the education of building automation engineers at a technical university. Results show that the implemented practices have fulfilled the needs of COVID-19 times, improved student's interest and performances, and identified the process, practices, and tools for implementing distance learning to handle future emergencies, pandemics, and other situations.
- Farahani et al. [10] discussed that blended learning and objective structured clinical examination-based practices can improve the pharmacist's abilities to conduct management of medication therapies and counselling of patients by physicians over medicines usages and prescriptions. Thiis study is performed to assess and improve student's abilities using a blended learning program integrated with structured clinical examinations for pharmaceutical consultations with patients of Type 2 Diabetes Mellitus. Results show significant improvements in students' knowledge and abilities in handling diabetic patients. Students have also responded with positive feedback over the implemented program.

Likewise, various surveys are conducted in recent times to realize the importance of blended or associated learning practices in schools and higher education. This survey aims to identify the importance of different Blended learning practices, processes, tools, techniques, programs, and frameworks proposed in recent times. It has been observed that this learning technology is found to be very effective worldwide during COVID-19 times. Thus, this work has prepared a list of recently practiced Blended learning experiences at different institutes and universities worldwide. Additionally, the objectives, outcomes, individual observations, and comparative analysis of various studies have been performed. Specifically, the objectives of this survey are explained as follows.

- To prepare the Blended, Online, and Hybrid learning practices followed in recent times (including both COVID-19 and non-COVID-19 times).
- To provide a comparative analysis of Blended, Online, and Hybrid tools, Techniques, Frameworks, Policies, and Practices used in recent times for improving student's performance and learning experiences.
- To discuss the importance of Blended, Online, Hybrid frameworks adopted in recent times for small scale implementation (single course) to large scale (complete discipline).
- To prepare case studies showing the recent practices followed at the author's institute in promoting the Blended and Online practices in various courses, the efforts, observations, outcomes, and future directions.

In this work, the review process starts with searching the articles from important indexing and search databases like google scholar, PubMed, Web of Science, and Scopus. Figure 1 shows the literature review processes followed in preparing this survey.

This work is organized as follows. Section 2 discusses the traditional learning practices, important frameworks adopted in recent learning practices, their outcomes, and shortcomings. Section 3 discusses the Blended learning practices, types, and their importance in different learning environments (especially during COVID-19 times). Section 4 discusses the various tools, techniques, and frameworks. Section 5 presents the Blended learning programs, their importance, and a comparative analysis of the recent adapted program in different universities. Section 6 describes the importance of mobile Blended learning practices of recent studies. Section 7 presents the author's real-time implementation and case studies useful for Blended learning model analysis. Here, two universities (University of Petroleum and Energy Studies (UPES), Dehradun, India, and Jaypee Institute of Information Technology (JIIT), Noida, India) experiences and case studies to implement Blended learning during COVID-19 times are described in detail. Section 8 presents a discussion over the findings of this survey. Section 9 presents the conclusion and future directions.

II. TRADITIONAL LEARNING PRACTICES

Traditional learning practices include face-to-face interaction and directing of the students to learn through memorizing and reciting techniques. This type of technique do not develop critical thinking, problem-solving, and decision-making skills. Thus, they are passive rather than active participation-based learning. Various other challenges of traditional learning are listed as follows [4][11].

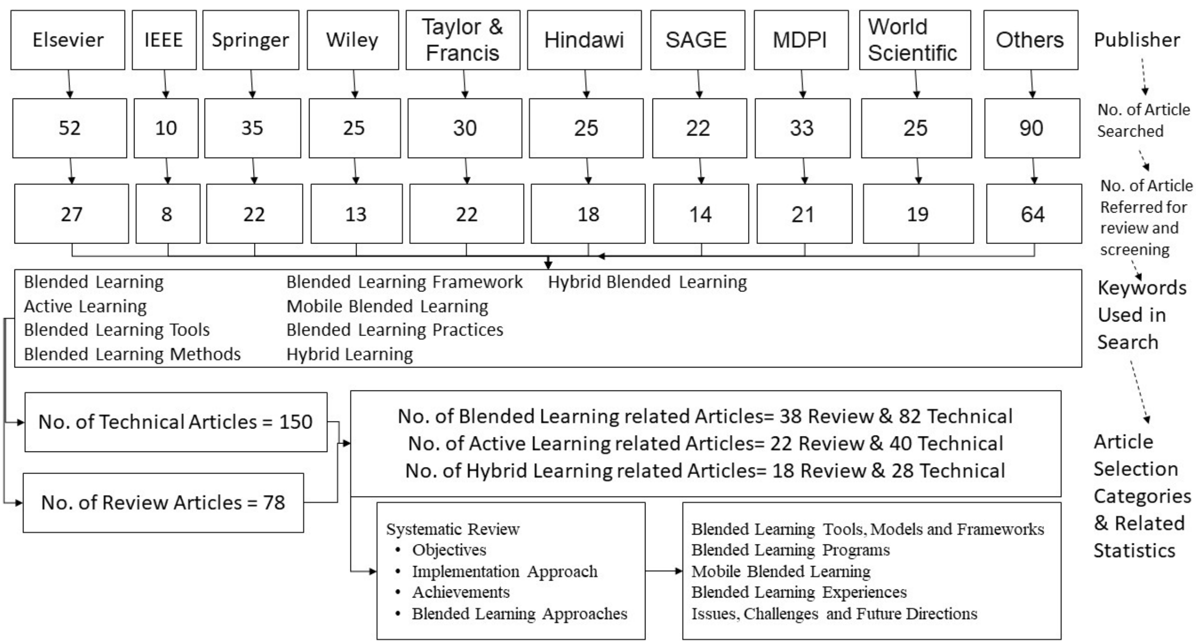

Figure 1: Literature review process

Table 1: Comparative analysis of learning approaches

Component	Traditional Learning	Online Learning	Blended Learning
Classroom	Face to face	Online	A balance between Face to face and Online
Location for Classroom	Physical presence in the classroom is mandatory	Anywhere (Flexible)	Anywhere (Flexible)
Laboratory Experimentation	Face to face	Online	A balance between Face to face and Online
Study Material Distribution	Individual Subject Teacher	Individual Subject Teacher Group Subject Teacher	Individual Subject Teacher Group Subject Teacher
Method of Study Material Distribution	Hard Copy, Soft Copy	Soft Copy	Hard Copy, Soft Copy
Online Support	None	Quiz/Assignment submission, lecture delivery, group discussions, Exam conduction, automated and manual answer sheet evaluations and marking	Quiz/Assignment submission, lecture delivery, group discussions, Exam conduction, automated and manual answer sheet evaluations and marking
Use of Online Technology and Tools	Not Mandatory	Mandatory	Mandatory
Interactivity with Students	Fully interactive sessions	Partially Interactive	Flexibility to choose fully interactive (using face-to-face interactions) or partial interactive (online) based on contents to be covered.

- ***Basic foundation knowledge***: In this challenge, core content knowledge competencies of core disciplines and cross-disciplinary knowledge or synthetic knowledge is required to be covered in 21st-century competencies for modern learning practices. The core or cross-disciplinary domains include English, mathematics, science, geography, history, government directions, and economics. A disciplinary way of thinking and learning patterns include understanding the domains by applying a mathematical way of thinking to handle real-time problems and issues, and a scientific way of understanding the problem's environment. In addition to core discipline knowledge, cross-disciplinary knowledge has its importance in demonstrating the application of knowledge to a new context for achieving certain objectives and goals. Cross-disciplinary knowledge is possible in multiple ways. It can be gained either by directly interacting with other person. or support of digital media can be taken to develop the ability to understand, organize and learn important information.
- ***Meta knowledge***: The important skill included in this category is how to build and improve foundational knowledge. The important categories in this process include problem-solving and critical thinking, communication and collaboration, and creativity and innovation. Problem-solving and critical thinking include cognitive skills. The cognitive skills help in establishing economic and social domain knowledge to interpret information and develop decision-making abilities. In problem-solving, critical thinking can be utilized for solving specific problems or issues with well-defined end goals. Communication and collaboration is another category in meta-knowledge that demands to development of the abilities for effective oral, written, and non-verbal media communications. Communication includes the skills required for effectively conveying our message and respectfully listen to others. In the 21st century, it is requirement to enhance the ability to use digital media for effectively conveying the message. Collaboration is additional to communication that includes the respectful and effective working style, the ability of an individual to have flexibility, willingness to active participation, and group and individual efforts in meeting the group goals. Creativity and innovation is another meta-knowledge factor for improving the learning abilities. In this, the generation of novel and worthwhile tangible or intangible outcomes are included. Further, it builds the ability to measure and evaluate the effectiveness of model ideas or products to achieve specific targets.
- ***Humanistic Knowledge***: This is another learner's parameter to improve self and its location abilities from a social and global context. This parameter considers life and job skills, cultural competence, and ethical and emotional awareness. Job and life skills build learning abilities to gain that knowledge that provide them competencies beyond classroom learning. This is lifelong learning that moves around three things: effective management and organization of any form of effort, better coordination and organized information, and development of tangible or intangible ideas or products.

- ***Lesser satisfaction and Efficacy***: In the case of face-to-face learning, students' satisfaction in theoretical, practical, or teacher's planned activities is lesser compared to that in online learning. There are various reasons for this including (i) lesser time to cover the subjects and handle individual student's queries, (ii) scheduling extra face-to-face class increases student's expenditures, and (iii) lesser chances of every student to clear their doubts.
- ***Difficult to carry study material in the classroom:*** It is usually difficult for students to carry books and study material in the classroom for doubt clarification and reading. Online learning provides a comparatively better option. In case, a student forgets to carry the textbook then he/she has to either go without it or take the help of a fellow student.
- ***Additional Expenses:*** In face-to-face learning, every student has to bear the additional cost in terms of travel and/or parking for attending classes. This can be avoided using online learning.
- ***No flexible schedule:*** Face-to-face learning has fixed class timings. In case, lecture recording facility is available with face-to-face learning then recording devices add cost to learning. In the case of online learning, the university provides the use of toolkits that has an inbuilt lecture recording facility or recording can be asked on request. Thus, online learning has more flexibility compared to face-to-face learning.
- ***Difficult for working professionals to continue academic activities:*** It is difficult for working professionals or part-time employees to continue face-to-face learning if they have a day-time job or other responsibilities. The lecture's schedule may not fit the job's schedule.
- ***Not suitable for pandemic situations:*** In recent times, it has been observed that face-to-face learning is not allowed during COVID-19 times, and online learning is preferred. In such situations, when face-to-face interactions are avoided, and social distancing has to be

Table 2: Comparative analysis of tools for E-Learning

E-Learning Tools	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
Blackboard [12]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BrainPOP [13]	×	✓	✓	✓	✓	✓	×	×	✓	✓	×	✓	✓	✓	✓	×	×	×	×	×	×
Buncee[14]	×	✓	✓	✓	✓	✓	×	×	✓	✓	×	✓	✓	✓	✓	✓	×	×	×	×	×
Edmodo [15]	×	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×
Edpuzzle[16]	×	×	✓	✓	✓	✓	×	×	✓	✓	×	×	×	✓	✓	×	✓	×	✓	×	×
Edublogs[17]	×	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×
FeatherCap [18]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
Flipgrid[19]	×	✓	✓	×	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	×	×
GoClass [20]	×	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×
i-Ready[21]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IXL[22]	×	✓	✓	✓	✓	✓	×	×	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×
Kahoot[23]	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	✓	✓	✓	×	×
Khan Academy [24]	×	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	×
Microsoft Tools[25]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MIT Open Courseware [26]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×
MobyMax[27]	×	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×
Moodle [28]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
Nearpod[29]	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	×
Open-LMS-Blended [30]	×	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×
Padlet[31]	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓	×	×	✓	✓	✓	✓	✓	✓	✓
PlayPosit[32]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Prezi[33]	×	×	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓	✓
Prodigy[34]	×	✓	✓	×	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	×	×
Quizlet[35]	×	✓	✓	×	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	×	×
ReadWorks [36]	×	✓	✓	×	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	✓	×	✓	✓	×	×
reveal.js [37]	×	✓	✓	✓	×	✓	×	×	×	×	×	✓	×	✓	✓	✓	✓	✓	×	✓	×
Richie [38]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Smore[39]	×	×	×	×	×	✓	×	×	×	×	×	✓	×	✓	×	×	×	✓	✓	×	×
Socrative[40]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×
YouTube[41]	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	✓
ViSH [42]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
Zeam[43]	×	×	×	×	✓	✓	×	×	✓	✓	✓	×	×	×	×	✓	×	✓	×	×	✓

A: Objective exam conduct option, B: Subjective exam conduct option, C: Online evaluation, D: Individual student/employee performance details and statistics, E: Online lecture delivery (one-way communication), F: Lecture material upload, G: Quiz Conduct (Objective type), H: Online Lab Conduct, I: Video lecture preparation, J: Audio lecture preparation, K: Video-based teacher-student interaction (two-way communication), L: Chat-based teacher-student interaction, M: Audio-based teacher-student interaction, N: Board and annotation features for lecture contents, O: Feedback and Survey system, P: Creation and Customization of Student groups, Q: Teacher dashboard for course reports, statistics, and analytics, R: Student/employee bulk email and announcement system, S: developed for school (junior education) system, T: developed for higher education, U: developed for professional businesses ensured, online learning is the only viable option.

Table 1 shows the comparative analysis of traditional, online, and blended learning practices. The comparative analysis shows that all types of learning have their importance, advantages, and disadvantages. For example, online and blended learning practices are found to be useful for learners during pandemic times. However, face-to-face interactions give more benefits to a teacher or subject expert in handling/controlling the class. Table 2 shows the comparative analysis of important online and blended learning tools developed and used in schools, universities, and businesses for teaching and learning.

A. E-Learning Frameworks

E-learning platforms play important roles in recent times. It accommodates the need of learners such as the usage of mobile and other digital devices, personalizing the contents, self-pacing the learning, and finding the appropriate study material, and lecture notes. With the comfort and requirements of learning, e-learning platforms (i) accommodate everyone's needs, (ii) lectures can be repeated, stored, and taken any number of times,(iii) create an ability to learn with modern tools and access the required updated contents with less access time, (iv) faster delivery of lecture reduces learner's time,(v) able to accommodate a large set of learners (i.e. improve scalability), (vi) improve learner's consistency, (vii) reduces costs because of fewer costs involved in training, (viii) traveling, course material access, and accommodation, and (ix) environment-friendly learning. E-learning platforms are useful to every business requiring regular employee training. Using these platforms, a teacher or subject expert can enroll the trainees, prepare course-related details, perform learning experimentations, add new articles/study material/ references. The administrative staff associated with e-learning platforms can arrange logistics, and promote a course (in case of a school or university) or product (in case of a business)-related training. A student or learner gets the time to explore the possibilities of courses, prepare an individual preferred list, and enroll as per his/her needs. A set of users or learners will be able to send/receive query messages, enquire about courses and other details, and can directly interact with university/college/school/training-unit for their doubts at any time. Various e-learning frameworks/models have been discussed in recent times [44][45]. Three e-learning models are briefly discussed as follows.

Alseelawi et al. [44] discussed the development of an e-learning platform. The aim of developing this e-learning platform is to provide an interactive environment for learners. The developed program is for teachers and students in Iraqi universities. Here, a multi-layered architecture is proposed in which each layer functions independently of other layers. Here, the layers include a user interface, business access, data access, and database. The user-interface layer also known as the display; the layer is for user-application interaction. Here, a user can interact with the e-learning framework and use system functionalities. Here, the business access layer is used to receive the data from the user-interface layer and pass it to the data access layer. The data access layer stored the data in the database in the pre-defined schema. Further, it helps in retrieving the information from the database as well. Finally, the database layer is to securely store the information.

People–Process–Product (P3) Continuum Model: In [45], the P3 model is proposed for an e-learning platform. P3 follows a holistic approach as shown in Figure 2. This model helps in developing high-quality course contents that are usable in the e-learning platform. Additionally, this model also helps in content submission and maintenance as well. It has been analyzed that this model is useful in

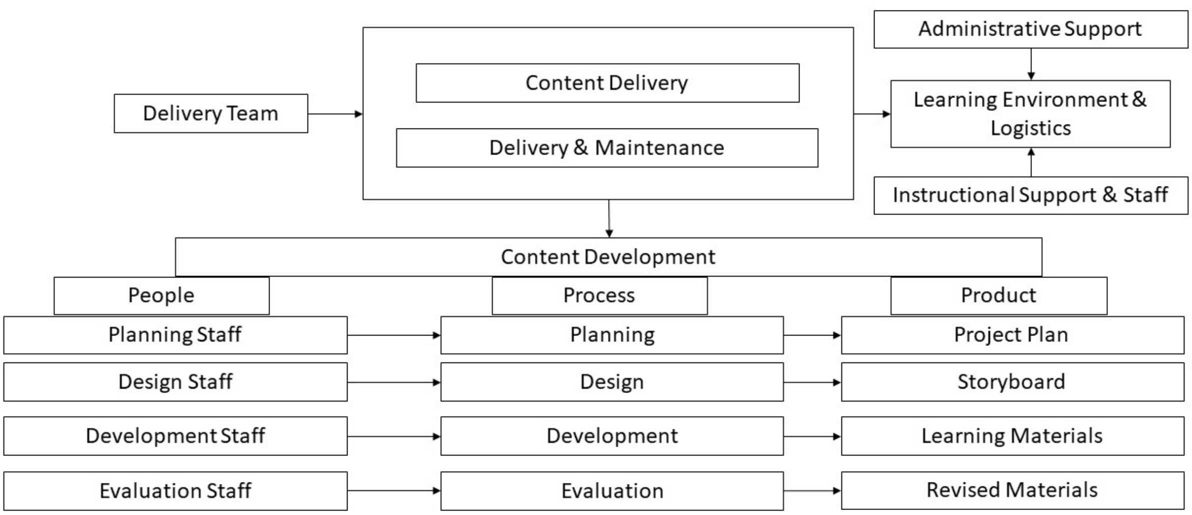

Figure 2: P3 model [44][45]

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improving educational platform development by considering the requirements of the modular approach. As shown in Figure 2, the P3 model considered the team in planning, design, development, and evaluation in parallel to plan, design, develop and evaluate the e-learning contents respectively. Thus, there are project plans, storyboards, learning materials, and revised materials as outcomes. In parallel, the delivery team uses developed content to be delivered to learners with required administrative, managerial, and instruction support and staff.

Smaili et al. [46] proposed a sustainable e-learning system. This system is developed to handle dropouts in schools. Here, basic idea is to provide every possible opportunity to the learner to complete their education. The proposed model applies an adaptive e-learning approach in exploiting the database of user's traces with the system. This analysis is used to improve the system features and capabilities. This system uses an ant colony optimization algorithm in determining the career path and recommending the best possible courses to learners. In recent education systems, it has been realized that the development of an e-learning system with a formal classroom approach is a sustainable approach. In parallel, MOOC (Massive Open Online Course) platforms are also getting popularity and major usage in education. This is because of its ability to handle a large number of users under one umbrella irrespective of whether they belong to one or diverse educational and cultural backgrounds.

B. COVID-19 Forced Online and E-Learning

This section discusses the role of e-learning during COVID-19 times followed by the changes that the pandemic brought in job characteristics. Kulikowski et al. [47] identified the use of 'emergency mode' in pandemic times. It has been observed that the teaching and learning process in education instructions are switched completely to online and e-learning systems. This trend is observed in all strains of COVID-19 that lead to either partial or complete lockdown. Kulikowski et al. [47] correlated the education practices of COVID-19 times with job characteristics in the 'Job Characteristics Theory' model. This study discusses the motivational job characteristics of a teacher. These characteristics are briefly explained as follows [47].

- ***Task Identity***: In [47]-[49], Hackman and Oldham defined task identity. Now, it has been realized in COVID-19 times that many reasons put teacher's task identity in uncertainty. The first reason includes the uncertainty to end the COVID-19 situation. This leads to a confusing state that whether the teaching will continue online or there will be a nearby chance to shift from online to blended or face-to-face mode. This situation put task identity unclear because there was not a well-defined mechanism to assess when and what contents will start or end at a particular time. The second factor includes the lack of teacher's practice over e-learning tools. Here, a perception is created among teachers that they will not be able to provide sufficient knowledge because of forced online and e-learning platform usage during COVID-19 times. Third, e-learning during COVID-19 times puts contextual and organization constraints. Here, teachers believe that e-learning will not be sufficient to provide the necessary teaching. For example, engineering courses will not be taught successfully because of the lack of availability of tools to teach laboratory experimentation that may need synchronization with theory contents.
- **Task Significance:** Hackman and Oldham [47]-[49] defined task significance, and they have given importance to impact over others live in this parameter. Task significance is higher in face-to-face education because this is a direct way to deal with others and understand others, and their need in a much efficient way. COVID-19 enforced e-learning has diminished the importance of this parameter. There are many reasons for this. For example, lack of experimentation led to theoretical learning only. Students will not be able to get the necessary skills that might have improved their job skills and lives. It has been observed that teachers need psychological support during COVID-19 times as well. Lack of support does not motivate them to teach in absence of sufficient resources.
- **Skill Variety:** Hackman and Oldham [47]-[49] defined skill variety, and they considered 'variety to perform different activities' is the key parameter to measure this. Now, skill variety is observed to be limited during COVID-19 times because of lack of e-learning practices, a perception that e-learning platform training is required well before its usage, limitation of resources in e-learning platforms, and difficulty in executing a large set of teaching and content preparation activities to smoothly run teaching using e-learning platforms.
- ***Feedback***: Hackman and Oldham [47]-[49] defined feedback, and they considered ' information about the effectiveness of employee performance is the key parameter to measure this. Now, it has been observed that feedback collected during COVID-19 times does not truly reflect the effectiveness of an employee's performance. This is because feedback is developed over some time by regularly observing the teacher and his/her activities. These activities were limited during COVID-19 times. Thus, feedback does not reflect true effectiveness. Likewise, lack of standard online procedure to collect feedback, student misleading entries, lack of practical exposure to students, and possibilities of monotonous theoretical course delivery were other factors that were major hurdles in getting true feedback.
- ***Autonomy***: Hackman and Oldham [47]-[49] defined autonomy, and considered 'the degree to which the job provides substantial freedom, independence, and discretion' as an important parameter to measure this.

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COVID-19 has put many constraints on teaching. Thus, the teacher's autonomy was not possible. In autonomy, the teacher can execute his/her planned set of activities, perform teaching experimentations, constitute student groups to perform more innovative, and open knowledge sharing sessions with better control, and many more. All these were not possible with full autonomy.

- ***Social dimensions of the work***: Hackman and Oldham [47]-[49] defined social dimensions of the work and considered the degree to which work required to deal with others, and the amount of other's feedback. A teacher has to play many social dimensions in their job. This includes dealing with teaching staff, students, parents, and other administrative people. All sets of interactions give different dealing and feedback. In face-to-face interactions, there were set of bonds, verbal feedbacks, cognitions, and emotions that were lacking during COVID-19 times, and with the usage of e-learning, and online platforms. The absence of these face-to-face interactions and delay in response from either side (student, staff, or teacher) created fewer social interactions. Altogether, this created a negative perception of e-learning and online platforms.

C. The Conception of Blended Learning

Blended learning is an educational concept that allows technologies to be combined with traditional classroom practices. It creates a provision to integrate any teaching pedagogy or approach that includes constructivism, behaviorism, cognitivism, etc. It integrates digital/online modalities with face-to-face learning [50]. The blended online learning approach is a practical strategy to combine the usage of both synchronous and asynchronous modes of learning [51][52]. Lapitan et al. [51] discussed one such strategy. The Discover, Learn, Practice, Collaborate and Assess (DLPCA) is an effective strategy that allows both synchronous and asynchronous sessions, and gives a "whole-class" teaching experience. In [52], this has been experimented with in chemistry courses, and it has its positive impacts on teaching and learning. As blended learning provides provision to conduct group teaching, it has been observed that this reduces the stress and burden of preparing study materials.

III. BLENDED LEARNING PRACTICES

Blended learning is widely used by universities and colleges for open education and distance learning. Various meanings of blended e-learning include [1]-[4][53]-[56]: (i) providing both face-to-face and online education option to teacher for lecture delivery, communication and concentration over individual student, and ensuring training using every possible means, (ii) enriching the value of conventional/traditional learning with advanced learning tools, techniques and technologies in order to meet the global and future challenges, (iii) increase the teacher's capacity with novel delivery tools and learning styles such that it increases students interest and performances, (iv) boost the use of latest electronic tools and technologies for better teacher-student interactions and communications by removing the traditional barriers, (v) availability of computers, digital devices and internet make it possible for everyone (especially living at remote places) to have education of his/her interest, (vi) helps in continuous evaluations such as progress made in learning process, and in depth performance analysis, accessing the stored lectures, experimentations, and other learning material as and when it is required from any place, (vii) flexibility to extend the traditional learning with transformation level of learning practices that include in depth learning approaches, and (viii) increase the active learners count, their knowledge levels, and subjective knowledge learning with dynamic ways. Various blended learning challenges are listed as follows [4].

- ***Availability of Blended and Online Learning Choices***: In developing countries, the choice of blended and online learning tools was limited. Every university/school does not support blended or online tools or was not planned at the start of the course during COVID-19 times.
- ***Availability and Speed of Internet Connectivity***: In blended learning, asynchronous teaching may not be accessible to students because of no internet availability or variation in the speed of internet connections.
- ***Lack of tools for Physical, Analytical, and Experimental Courses***: In engineering, there is a need for infrastructure to provide physical, analytical, and experimental work in different engineering courses. This is not possible every time with blended or online learning practices. This is because of the lack of convenient tools to write mathematical and experimental work. For example, IoT devices and associated commercial software are usually available in university laboratories that might not be possible for every student to access.
- ***Internet Overloading***: A large set of IT companies are already working over Work-From-Home (WFH) model. In parallel, if all students and faculty members will execute the training online (both synchronous or asynchronous) then it will be difficult to ensure a stable and easily accessible internet and connectivity platform. Further, there may be security and privacy concerns that may arise during sharing of materials.
- ***Unwanted disruptions***: WFH model usually creates many disturbances from home. These disturbances include interruption from family members, necessary construction or maintenance work going on in nearby places, or inaccessibility of IT services.
- **Lack of tools for examination and evaluations**: In complete online blended learning, conduction of exam majorly depends upon open book set of problems.

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Although there are many tools to observe the student activities during the examination the majority of them have a shortcoming. Thus, a standard set of practices are required to be designed at the national level to follow the examination pattern during online blended learning.

A. Models of Blended Learning

This section discusses various blended learning models and their uses in recent times. Blended learning models are found be classified into the following forms (i) Station Rotation Blended Learning (SRBL), (ii) Lab Rotation Blended Learning (LRL), (iii) Remote Blended Learning (RBL), (iv) Flex Blended Learning (FBL), (v) The 'Flipped Classroom' Blended Learning (FCBL), (vi) Individual Rotation Blended Learning (IRBL), (vii) Project-based Blended Learning (PBL), (viii) Self-Directed Blended Learning (SDBL), (ix) Inside-Out Blended Learning (IOBL), (x) Outside-In Blended Learning (OIBL), (xi) Supplemental Blended Learning (SBL), and (xii) Mastery-based Blended Learning (MBL). These blended learning forms and recent practices in this area are explained as follows.

- ***SRBL***: In SRBL, students rotate through the learning stations. These rotations are either pre-defined on a fixed schedule or variable as per the teacher's discretion. SRBL can be considered as a blended learning model provided at least one of the learning stations must be online. SRBL is found to be implemented in an easy way [53]-[58]. For example, a teacher can make small groups and have them rotate through different learning stations as shown in Figure 3. In recent times, SRBL is applied in various studies. Few recent studies, their objectives, and observations are explained as follows. Nida et al. [54] experimented with the station rotation blended learning model to determine the model's effect of creative thinking skills in math courses and reducing the math anxiety among public junior high school students. The research method applied for this study is quasi-experimental by sampling. Further, a stratified cluster random sampling technique is applied for samples and analysis in three schools (Mojolaban 1 Public Junior High School, Majolaban 2 Junior High School, and Grogol 3 Public Junior High School). In data collection, a written test and questionnaire methods were followed by one-way multivariate analysis of variance method for data analysis. In results, it is observed that rotation blended learning models were better for this study on mathematical creative learning models compared to the direct learning model. Further, the comparative analysis of the rotation blended learning model with flipped classroom learning and direct learning model shows that the proposed study is effective for students in developing mathematical creative thinking skills and reducing math anxiety. However, the direct learning model and flipped classroom can be selected as the best alternative. Saragih et al. [55] concentrated on digital education 4.0. Thus, the need to have online learning practices is given more importance over face-to-face. In the digital education 4.0 model, economic technology and information are found to be important for help, search, analyze and explore the information about learning. All these learning options are feasible using digital devices, the internet, and learning tools and technologies. Thus, Blended learning is a viable option that combines face-to-face learning models with e-

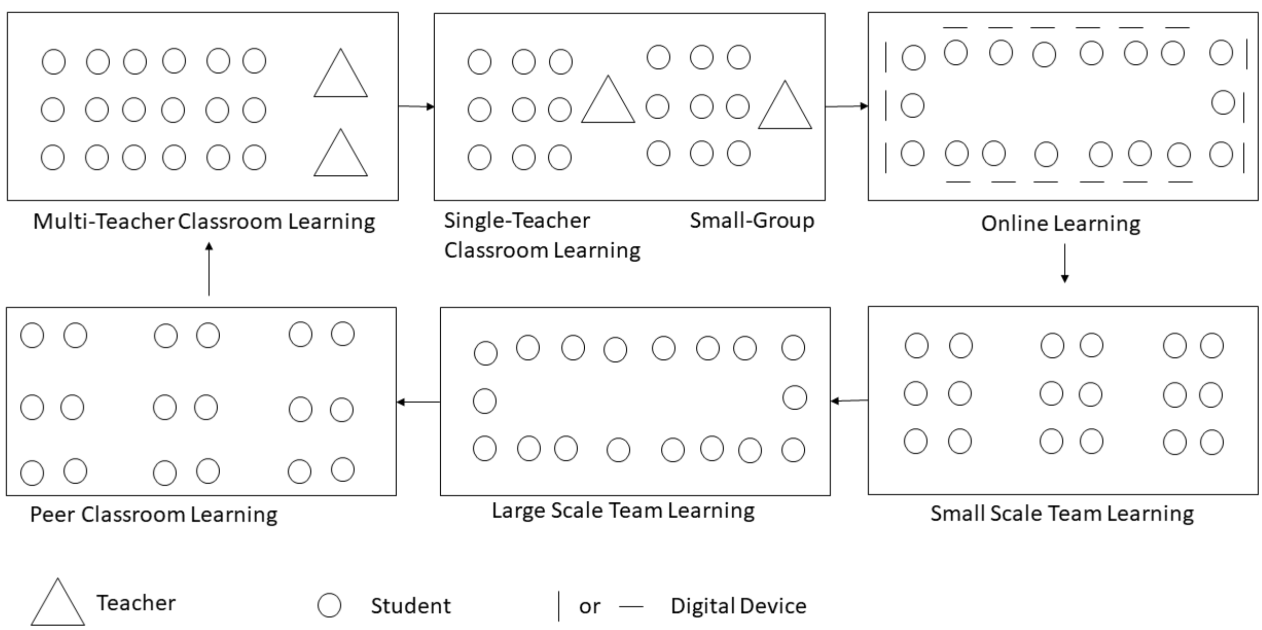

Figure 3: Station Rotation Blended Learning (SRBL)

learning models. Both e-learning and face-to-face, learning options provide an opportunity to experiment with learning styles for enhancing student's interest and performance. Bariham et al. [57] practice the online learning approach over 972 students with 84 social studies teachers from 12 secondary schools. In this experimentation, those schools were selected that were well equipped with ICT laboratories and well connected with electric supply for hybrid online and blended learning. This study has briefly discussed the importance of different blended learning approaches especially station rotation blended learning. In observations, it has been found that infrastructure was well equipped for different types of learning, but the staff was not trained to handle digital technologies. As a result, the rate of students' success in integration with digital technology for social studies was very limited. Thus, this study has recommended integrating different learning practices in education with well organized in-service training for faculty members, integrate modules for online learning tools and platform knowledge/training to both teacher and students, formalizing policies and procedure for best learning practices in schools, and regular updating of training modules. McCollum [58] identified that the impact of blended learning practices on students' achievements is not explored sufficientlly. This study has applied SRBL to second-grade students and compared the results with the traditional learning model. In a comparative analysis, two schools were selected that comprised 115 students of second grade and divided into three sections. Here, Measures of Academic Progress (MAP) an assessment product from Northwest Evaluation Association (NWEA) is used to measure the performance. Using SPSS software, data was statistically tested with a t-test and it has been found that there were statistical differences between fall and spring assessments in mathematics and reading scores of students. However, there was no difference in observations concerning males and females registered for a blended learning course. The observations for blended and traditional learning were similar. To evaluate the scenario, the experimentation was conducted over the identification of those learning features that were unique among all schools under observation. This approach makes it easy to apply for the experimental work in other schools that shows similarity in learning parameters. Fazal and Bryant [59] conducted the blended learning experimentation at the school level. Here, 6^{th} grade students were under examination. In this experimentation blended learning for the mathematical subject was considered, to compare the results of blended learning outcomes with traditional learning. As a result, it is observed that blended learning is a feasible and effective solution for teaching mathematics. Further, it is also analyzed that this way of teaching improves students' understanding as reflected in their grades. Khairiree [60] conducted the blended learning experimentation in different domains. Here, this learning was used to teach courses to Airline business class students at International College, Suan Sunandha Rajabhat University, Thailand. The experimentation results reflect that selection of blended learning with online lessons increases interest of students in classes. As compared to student's attendance during traditional learning, blended learning showed higher attendance. To teach online lessons, various digital devices including smartphones, tablets, computers, and laptops were allowed for use. Here, every arrangement or permission was given that was required to understand and solve problem-solving activities. With this ability, students were more engaged in classroom activities compared to traditional face-to-face practices. Thus, the use of online learning and digital devices made the classes more interesting. In [53], the SRBL model was applied over to third grade students over one semester. In SRBL-based learning experimentation, a pre-defined set of activities include preparation and conduct of group interviews and questionnaires. Further, two sets of activities (positive and negative theme-based) were planned to observe the outcomes of the considered model. The positive set of activities include technology understanding, fun time, other's support, and help, etc. The negative theme-based set of activities include complex problem-based challenging work and technology understanding[61]. Thereafter, analysis was performed to find out the effectiveness of the proposed approach.

- **LRBL**: LRBL is also a rotational mode. In this model, a teacher or expert has the flexibility to implement the pre-defined rotation model or applying the dynamic model as per his/her understanding, and change in the environment. In this model, one station should be fixed with online learning, and the other may follow online or other available learning options. In literature, different experimentations are discussed to implement this model in real time scenarios. Some of the experimentations are discussed as follows.

Cai et al. [62] discussed the LRBL mode application in Chinese higher education. This model is applied initially over 114 students to observe the outcomes and student's perceptions. Here, computational thinking is considered an important parameter in evaluation. As a result, it was observed that it is not difficult to integrate this model with Chinese education, and computational thinking skills were also improved in learners. Thus, identification of unique parameters, selection of rotation model, and analysis of results was recommended for higher education in china. In Hubei University of Education, Cai et al.[63] applied the blended learning model over more than 250 students from different classes. This implementation is unique because learners were taken from a different set of classes to observe the outcomes. Further, the model was implemented in two phases followed by a feedback process. In results and feedback, analysis shows that the LRBL model is useful in the Chinese higher education system to improve learner's skills. In addition to improving the skills, student's grade performance was also improved. In [64]-[66], requirements to implement LRBL model are proposed. According to these requirements, a dedicated lab and associated faculty member is mandatory to implement the proposed process. Here, students have the flexibility to select any lab station, apply the rotation model, and follow the fixed schedule. In Togliatti State University, Kirillova et al. [6] applied the blended learning model in English teaching courses. This model was applied to Master-level students, and Project-Based Learning is highly recommended for teaching a foreign language. There were major hurdles in teaching foreign languages, and this is removed using the proposed model. As a result, it is found that the communicative competence problem of Master-level students was solved in higher education at the university level. In project-learning experiences, there are four basic elements including face-to-face learning, a LearningApp-based web platform, MOOC Coursera, and reading science. Kirillova et al. [6] conducted the survey and gave the observation to use project-based learning to solve foreign language-based communication barriers. In this survey, it has been found that the effectiveness of the blended learning model can play important role in removing the learning barriers and improving the student's interest and performances. Further, an effective blended learning model can play important role in developing an environment that drives learning pathways transparently and establishes a standard learning process control strategy. Hover and Wise [67] investigated the implications of twenty-first-century digital learning practices using digital devices and tools. This work has used the survey data for analysis. This data is collected from third, fourth, and fifth-grade teachers that have applied face-to-face and digital devices-based online learning practices and used multiple-levels of Bloom's taxonomy. It is observed that a planned online-learning practice can improve higher order thinking skills including analyzing, evaluating and creating novel aspects from learning environment. The analyzed system is discussed for online-learning during COVID-19 times as well. It is recommended to use SRBL and LRBL in such scenrios because this contributes to enhancing student interest and performance.

- **Flex Blended Learning (FBL):** In FBL, online learning is the backbone of student learning. However, teacher's face-to-face support is available through various activities such as small-group project-based interactions, one-to-one tutoring, group-discussions, and classroom activities. In this type of learning, the teacher is available on-site for any support and the student is having a well-planned schedule for his/her learning. Various studies conducted using FBL mode in recent times are briefly discussed as follows.
  In [68][69], the importance of FBL is discussed for professional students and the distance-based education system. FBL provides a fluid learning schedule that is useful for many working professionals registered in university-level programs.
- **FCBL**: Flipped classroom-based learning is a pedagogical approach of shifting the direct instruction-based group learning to individual learning that provides a dynamic, and interactive environment. In this environment, the teacher guides the students as and when they apply learned concepts which result in creativity. FLIP learning is having four pillars including flexible environment, learning culture, intentional content, and professional educator. Flexible environments enable a teacher to provide a group or independent study environment. Thus, students have the option to select the best suitable environment and time to learn. Here, the teacher has the flexibility of expectations from different students according to their timelines and assessment approach. Learning culture shift the learning pattern towards a learner-centric environment where those topics are selected for discussion or learning that find interest among students. This increases student's participation and promotes personally meaningful activities. International content is another FLIP learning component that provides a student-centric environment in which international content can be referred to maximize classroom interest. This component involves active learning strategies for increasing conceptual understanding and procedural fluency. The professional educator component increases student's professional dealing including interconnection among students and improve their instruction-based learning, ability to accept constructive criticism, handle controlled chaos in face-to-face classroom-based learning, and continually observe the students over their period of learning. Various recently practiced FCBL-based learning approaches are briefly discussed as follows.
  Thai et al. [70] examines the importance of FCBL compared to blended, traditional, and e-learning approaches. This comparative analysis is drawn using various parameters like learning performance, self-efficacy, intrinsic motivation, and flexibility. The FCBL-based experimentation was conducted in CanTho University, Vietnam with two instructional elements (lectures and guiding questions) using two different

modes (online and face-to-face). Results show that learning performance in FCBL was better compared to other learning approaches. Additionally, students have shown better performance in FCBL compared to their earlier learning modes. Sajid et al. [71] experimented with flipped classroom-based learning and compared the results with historical data. Results show significant statistical improvements in results. Students were satisfied with blended learning in terms of academic performance improvement, a new and effective learning approach, and exam preparation and concept clarification.

- **IRBL**: In individual rotation blended learning, students are allowed to rotate the stations with a pre-defined schedule prepared by a teacher by use of some software [55]. In [6][55][72], IRBL is discussed. The majority of these discussions are very basic and do not apply IRBL in real-time case studies. However, it has been clarified in studies related to IRBL that this approach has a pre-planned set of playlists. This playlist is scheduled and the student has the provision to rotate the stations and learn as per their convenience.
- **PBL**: In various recent studies [6], it has been observed that the PBL model is an effective approach to improve learning processes and practices. The student also finds interest in PBL learning models because the outcomes are good and useful for their career. Here, a list of PBL practices adopted in recent times is studied, analyzed and outcomes are discussed. Details of these practices are as follows.

  Kirillova et al. [6] surveyed different blended learning practices. In this survey, the importance of various learning practices, procedures and processes are discussed briefly. In observation, it is found that the PBL model is effective in foreign language communication issues using four components: four basic elements including face-to-face learning, a LearningApp-based web platform, MOOC Coursera, and reading science. All of this component analysis and their integration create interest among students to have better experiences and give comparatively improved performances. Armando et al. [73] studied the blended learning environment from the project learning environment perspective. Here, an emerging 5G technology-based project for a Portuguese nation is considered. This project focuses on developing a product named 5GOpenclasses. This project considers the design, development, architecture consideration, technological platform, and associated end-user application in focus. This process involves location-based service for the blended learning environment. From project implementation, and outcomes, it has been found that blended learning played important role in understanding the project components. The location-based service and assessment were useful to deal with the stringent real-time project requirements. Thus, it helped in completing the project parts on-time

  Other learning approaches
- **Other Models**: Various other blended learning models are discussed briefly in various studies but are not found to be applied in recent times [6][55][72]. For example, **RBL** model is a blended learning model that allows the students to use the online medium for their learning. This platform is useful in pandemic or situations where it is difficult for students to attend it. In **the Outside-In Blended Learning (OIBL)** style of learning, a non-academic environment through digital or physical presence is considered as a useful pattern during the start of learning but preferences are given to traditional classroom-based learning thereafter. Classrooms are considered as a place to collaborate, a safe place for sharing thoughts, perform creativity, and improve learners' work. This learning reserves the importance of guidance, teaching, and every other teacher support that exists in face-to-face learning style. In **the Inside-Out Blended Learning (IOBL)** style of learning, the learning ends within the outside physical classroom environment. However, a major set of activities are performed inside the classroom only. In this style of learning, less importance is given to online learning modules and the major focus is on classroom-based platforms. Mixed project-based learning is the best example of this type of learning. Here, teacher or expert feedback, support, content teaching, and motivations play important role. In **Supplemental Blended Learning (SBL),** online learning acts as a complement to face-to-face learning. Thus, the major focus is to improve learning through face-to-face interactions. However, support of online learning is taken to learn the additional contents. For example, conduction of online classes or exams during pandemic situations [74]. In **Mastery-based Blended Learning (MBL)**, both online and face-to-face learning styles are available and can run in parallel. The effectiveness of this type of learning is based on teacher or expert patterns of thinking, teaching style, and implementing the planned process. This learning style also varies with learners' activities, characteristics, and environment of interaction [75]. In **Self-Directed Blended Learning (SDBL),** both online and face-to-face learning is adopted. Both styles create a formal learning environment for the learner. In this formal environment, there is no specific degree or module that is necessary to be learned. This style is picked by those learners that need any specific type of spark, maintain learning in parallel to other necessary activities, and can support themselves with full autonomy and self-criticism.

Table 3 shows the comparative analysis of blended learning approaches discussed above.

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Table 3: Comparative analysis of blended learning approaches

Blended Learning Approach	Objectives	Conclusions	Pros	Cons
SRBL [54]-[61]	SRBL is implemented with different scenarios and objectives. For example In [57], learning practices were implemented for social science courses to handle teaching during COVID-19 times and connecting the students and teachers to have the best learning experiences. In [58], SRBL is applied to second-grade students for improving the student performances compared to traditional learning practices.	In learning practices [57], it has been found that there are certain courses for which integration of teachers and students with digital technologies would be challenging because of lack of training and policies. It has been observed that the collected data for two seasons (fall and spring) shows better learning outcomes for students compared to traditional learning practices. Further, no difference was observed between males and females.	A well-equipped learning environment would be available to everyone for handling learning practices in every situation [57]. In [58], experimental scenarios is generated after learning the patterns of studies in various schools, and it is highly recommended to use SRBL-based blended learning practices for improving student performances. In [60], blended learning activities were performed for students registered in airline courses. As result, the activity was found interesting for them as well.	Lack of policies and training might result in lesser teacher and student integration with digital technologies for learning practices irrespective of well-equipped ICT tools and other infrastructure [57]. In some studies [58][59], results are observed for non-engineering level courses. Thus, there is a need to repeat the experimentation for engineering courses before accepting the results.
LRBL [6][62]-[65][67][76]-[80]	LRBL model is found to be effective with different implementations. For example, Cai et al. [62] found that LRBL implementation for computational thinking course in Chinese higher education to improve student's performance. In [67], LRBL is applied with face-to-face and online-learning mixed-mode, and experiences of third, fourth, and fifth-grade teachers are analyzed.	In [62], it has been found that LRBL improves the student's computational thinking in higher education. In [63], LRBL is found to be effective for a large number of students in different courses. In [67], it has been observed that LRBL practices develop higher-order skills and subject-interest.	The successful implementation of this model is recommended for various higher educational studies [62]. In [63], it has been found that LRBL is effective in other courses as well. In [67], the LRBL practices develop higher-order skills that include self-analyzing, self-evaluating, and creativity. The major observations are analyzed during COVID-19 times.	There is a need to apply the model over multiple courses in the same discipline before recommending it to a large scale [62]. Large-scale implementation needs to focus on parameters for better observations [63]. In [67], LRBL and SRBL are applied for third, fourth, and fifth standard students. However, the LRBL practices need to be adopted for higher education for analyzing its impact.
RBL [81]-[86]	In [87], it has been observed that the RBL model can be applied to complete online assignments with the least interruption from a teacher.	In [87], it is observed that the RBL model is good for distance education.	The RBL blended learning model is useful for working professionals where assignments can be submitted online and teacher-student interactions are possible as per requirements [87].	RBL model is discussed in various studies but their real-time experimentation and implications are not available to study.
FBL [88]-[91]	In [68][69], it has been observed that FBL learning is useful for learning that require assignment-based learning and fixed schedule.	FBL is an effective approach for working professionals or part-time learners because it adds flexibility to accommodate non-academic activities in the learning schedule.	Assignment-based learning mode with a fluid schedule creates interest among working professionals to continue academic activities.	FBL model is discussed in various studies but their real-time experimentation and implications are not available to study.
FCBL [92]-[106]	FCBL provides wide flexibility to students and teachers to perform experimentation for their courses as per their preferred way of studying or learning. This learning aims to consider various parameters (like intrinsic	Wide-set of experimental studies is available to gain experience and apply this learning in different courses. The existing studies show that student learning	The flexibility in selecting the learning parameters improvements, and applying in different courses as per student and teacher interest increases this learning	Large-scale implementation of FCBL is not studied in recent times. In developing countries, student registration in university-level courses is very large. Thus, there is a need to

	motivation, learning performance, self-efficacy, and flexibility) and improve learning standards.	improves with this type of learning style. It is reflected in course feedback as well.	style's importance. FCBL applied to engineering courses shows that student interest increases in learning which in turn improves enrollment in subsequent years.	experiment, identify learning parameters, and observe the outcomes in these cases as well.
IRBL [6][55][72]	Studies show that a pre-planned set of the playlist with a pre-defined schedule provides the student an environment to rotate the learning stations.	Lack of experimentation in this type of learning does not give clear outcomes and benefits. Although students are having an option to rotate the learning station learning outcomes may vary with its implementation environment and associated parameters as well.	Like any rotation-based learning approach, IRBL also provides a provision to rotate the learning station with a pre-defined set of playlist activities for students. Here, the schedule of rotation is also pre-planned which avoids any conflict.	Lack of experimentation has not promoted this learning practice on a large scale. There is a need to identify the learning parameters associated with this type of learning and perform experimentation. This experimentation will be useful in designing effective mechanisms in different domains.
PBL	This style of learning integrated the learning environment with the project. Here, a classroom or real-time project can be executed with a blended learning environment to learn the project components.	In [73] blended learning is integrated with real-time projects. In observations, it has been found that blended learning is helpful in remote location-based project learning.	This learning gives better motivation compared to other learning styles because of project outcomes that are visible in tangible form or use in a real-time environment	Integration of real-time projects with every course is difficult. Project-based blended learning free-up contact hours which might not be possible in every course. Thus, it is not easy to integrate this type of learning into the curriculum.
Other Styles [75]	Additionally, there are learning styles like IOBL, OIBL, SBL, MBL, SDBL, and RBL. Each of these models has its own objectives. For example, IOBL focuses on non-academic environment learning through a digital medium during the end of the course. OIBL focuses on non-academic environment learning through a digital medium during the start of the course. RBL mixes online and face-to-face learning for improving the ability of learners who cannot pursue face-to-face learning. MBL depends on the teacher or expert's ability to manage digital or face-to-face environments. SDBL involves learners' ability to decide the medium, contents, and extent of the topic to be covered.	The outcomes of each model vary with the environment. For example, IOBL and OIBL focus more on creativity, physical interactions, and knowledge sharing, and learners' ability to learn. RBL and SDBL are more important for those learners who want to continue their learning along with other important tasks. RBL provides online as the primary way of learning. Whereas, SDBL depends upon the learner's ability. MBL outcome depends upon the expert's ability to manage the learning environment, and their knowledge.	Every other learning model has its advantages. These advantages are already discussed previously.	Lack of other model practices and discussions in different platforms does not provide a detailed report to analyze. Lack of statistical data is a major factor for being not able to analyze the models in detail.

B. Evaluation of Blended Learning

The foundation of blended learning is firmly rooted in empowering teachers to provide student-centric and high-quality instruction. It is a myth that the integration of technology into teaching-learning pursuits transforms traditional teaching into a blended learning approach. It is fairly the extent to which, the teacher exercises the ability to leverage technology towards personalizing and streamlining the learning process. An advantage that naturally follows is the facilitation of effective maximization of the impact of instruction time of the teacher. Providing an integrated learning experience is central to the idea of blended learning and flipped learning approaches. The clear differentiator from the use of traditional methods alone is that in blended modes there is access to a supportive environment, which can facilitate the device of customized and fluid student-centric instructional

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paths. These offer flexibility to the teacher to exercise variable and need-based interventions, targeted towards the ultimate goal of achieving learning. Given the nature of blended learning as a multi-feature innovative pedagogical approach, its implementation poses several challenges. The process is progressed through the implementation plan, well supported through pre-implementation considerations such as building and testing blended learning infrastructure, identifying individual roles of stakeholders including student, teacher, content developer and administrator. Once in progress, it is essential to assess the efficacy and efficiency of the process. Hence, there is a need to identify measures (predictors) to gauze its success in ascertaining the effectiveness. In the remaining part of this text, these measures are referred to interchangeably as, 'predictors for success of blended learning model'. In the light of these predictors, there is a regular revisit and revise of the existing process, to improve it. Assessing the success of blended learning essentially involves dependency on the quality of the course and the virtual study environment. Hubackova and Semradova reported in their work, that the success of blended learning depends on the ability of the student to adjust to the blended environment. It is also relatable to the student's perceived comfort in the use of tools and features offered by LMS [107].

Several studies reported the evaluation of blended learning. Yigit et al. [108] reported a study of evaluation of blended learning in delivering a course on algorithm and programming and concluded that blended approach promotes thinking abilities in algorithm development. Marchalot et al. [109] presented the use of blended learning in anesthesiology and critical care teaching and concluded a positive impact on participating students' knowledge. While evaluation of blended learning involves the assessment of specific parameters quantitatively and qualitatively, the present work is limited to the identification of predictors and their assessment qualitatively and subjectively. Assessment of the efficacy of blended learning encompasses consideration of some of the factors such as student characteristics and features of the design of blended learning environment. Student characteristics elaborated as behavioral attitudes, self-regulation, and comfort in using computers for learning, management of workload, social and family support, gender, and age. Blended Learning Environmental Design features comprise the quality of technology, availability of online tools, face-to-face support, and interactions of learners. The outcome of effectiveness is in terms of student satisfaction, ascertained through achievement on learning outcomes, performance, expression of intrinsic motivation, and knowledge construction [55]. Self-regulation in learning processes is an attribute of student or learner, where the learner learns, in a proactive manner, rather than due to learning being brought to them by way of specific instruction. Considering self-regulation as a personal attribute of an individual, tangibility associates with it, and quantifying it becomes a challenging task. A study by Bernard. L., et al, presented the development of a tool Online Self-Regulated Learning Questionnaire (OSLQ) and emphasized its reliability and validity in addressing the need for an instrument to measure self-regulation in the online and blended environment [110]. Through a study conducted at the University of Granada, Lopez-Perez et al. [111], reported, the interrelationship between student's perceptions and their learning outcomes. They concluded that the use of blended learning has a positive impact on lowering drop-out rates and enhancing performance [111].

The section below presents identified predictors of the success of the effectiveness of blended learning.

1. ***Adaptivity***: Personalizing instruction being one of the core objectives of the blended learning model, there is a strong emphasis on adapting the curriculum to the specific needs of each student. The adaptivity can be equated to the element of scaffolding, which is widely varied from the traditional 'one-size-fits-all' approach, where the need of the student is not considered while offering instruction. Continuing with the traditional approach presents a risk of advanced students becoming disengaged and bored, and the struggling students will experience frustration while dealing with difficult tasks. Adaptivity addresses this issue, as students struggling with particular skill areas have an opportunity to progress at their own pace, receiving support in form of scaffolding and instructions. On the other hand, an advanced learner gets to explore, innovate and seek support for the same from the teacher, in the process becoming more satisfied with the experience.

   Control overtime division of the teacher is another significant advantage. The teacher has an option to plan time between the students of both categories. The teacher can spend less time with those students who are mastering concepts with reasonable ease and progressing well. The other students can have access to more part of the teacher's time, to seek assistance on developing basic skills and move to challenge tasks.

   Adaptivity can be studied under the following two: 'Adaptive Instruction' and 'Adaptive Assessment'. The programs that implement the traditional approach treat all students at the same instructional level, and offer instructions, regardless of whether they have demonstrated mastery or show signs of struggle with curriculum, content, and skills. Along the same lines, offering the same assessment to all, too, defeats the whole purpose of being need-centric to the student. A truly adaptive approach is to be able to determine which students have not yet reached mastery and offer scaffolding and assistance on that particular skill and provide 'Adaptive Assessment' which is adjusted and tuned to the 'Adaptive Instruction' provided.
2. ***Granular Progress Record***: The record of student progress during online learning should be at a granular

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level, followed by a regular report back to the teacher. Failing appropriate records and reports leads to undermining the entire goal of providing a personalized approach. As the blended learning approach advocates different learning paths for different students, session to session, the monitoring of teachers, facilitated through systematic and structured data access, ultimately promises a journey towards the achievement of learning goals. Regular progress monitoring in real-time facilitates teacher assistance to concerned students promptly. The teacher can support the student who has encountered an obstacle and offer a remedy, which could be individual or small group direct instruction. The data helps the teacher to be targeted and time-efficient focusing on students most in need of help. Unavailability of student-wise granular level progress record leads to teacher groping in dark and ending up offering the same instruction to all students, without being able to assist with weak or obstacle areas.

3. ***Personalized Learning Plan:*** Blended Learning provides opportunities for enhanced student experience by way of offering personalized learning. The student can work at their own pace and focus selectively, dedicating more time to weak areas. While this provides several benefits to the student, it makes the task of the teacher more complex, in terms of keeping track of the progress of an individual student. The challenge of the teacher is to provide individualized direction and instruction, catering to individual needs and focus areas. The technology-tools of a blended learning environment come in handy in this context, where the teachers can make themselves equipped with real-time data of student progress. This facilitates the teacher to have fair access to granular information of student's progress. Analytics is the immediate next requirement over this data, to support teachers with specific decisions regarding providing appropriate instructions/strategies to each student. This takes the form of a formal individualized learning plan, which provides step-by-step recommendations for offering instructions, embedding assessments, and assessing learning.
4. ***Resource Sufficiency***: Blended learning provides opportunities to align learning processes with the pace of the learner, adjust as per real-time student data of performance and comfort. This facilitates the teacher to plan the classroom component of the students in a manner, most aligned to their struggling areas. To make this plan most adapted to the student, the technology supports in choosing and packaging appropriate instructional materials. Technology supports the selection of instructional resources to associate data of performance with instructional strategies. Instructional strategies are customizable to suit the individual learner. The crux is that the technical support is not only to identify the students who need support but also to assist the teacher in understanding, the mechanism to support them.
Coyne et al. [54] presented an integrative review outlining the educational approaches used in blended learning and discussed the use of resources such as simulation videos to teach clinical skills to health students. They concluded that the use of online resources such as video simulations may be a useful tool to teach clinical skills to students of health including nursing. Blended learning not only enhances the knowledge and skills of the students but also is increasingly acceptable by students, due to the flexibility it offers [54].

The above four predictors are quality indicators of the effectiveness of blended learning. Subjective evaluation of the same using standard instruments, in specific blended learning settings, is an interesting observation opening up several insights into its efficacy and efficiency in the education domain.

IV. BLENDED LEARNING TOOLS, MODELS AND FRAMEWORKS

In this section, we first present brief background knowledge and conceptualizations given by renowned researchers about models and frameworks, followed by varied tools used in this form of learning. Then, the motivations and strategies for using technology to reduce costs in blended courses are presented.

A. Models and Frameworks

Blended learning provides a unique learning experience by blending traditional classroom training with online training. However, combining different training methodologies is not very easy and the percentage of blend would depend on the content of your training and the audience. The different conducts can be adopted for the learning objectives. The appropriate equilibrium is needed between the components so that consistency can be seen while mapping the definition of blended learning as proposed by Graham and Friesen [112]. The definitions revolve around the delivery mechanism, which is bimodal. The definition claims to be using face-to-face or 'co-present' elements, and a computer-mediated element. This section discusses different classes of models and their characteristics used in blended learning.

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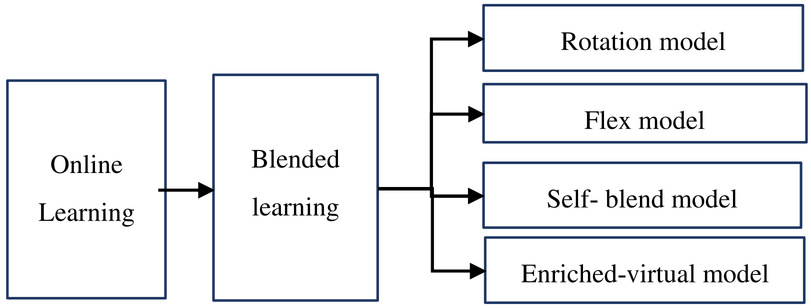

Figure 4: Blending learning landscape

According to Christian Institute [113], different blended learning models are used in training named Rotation mode, Flex learning, A La Carte Model, and Enriched virtual model. Figure 4 depicts the taxonomy reflecting the blending learning landscape [114]. The models are categorized based upon the literature suggesting executing the approaches involving blended learning. The explanation of the commonly used model is described detailing with the components and the techniques necessary to be incorporated for the blended learning approach [115].

Rotation Model: In this model of blended learning [116], a fixed schedule is followed and participants rotate between different learning modalities, one of which is online learning. The other training modalities could be a group activity, an instructor-led session, a group project or an individual assignment. The rotational model has four sub-models namely Station rotation, Lab rotation, Flipped classroom and Individual rotation.

Flex Learning: In this model, online learning forms the backbone of the participants' learning activity [117]. Learning is primarily self-directed through digital platforms. However, instructors are available on-site to provide support and guidance as needed. Each participant follows an individually customized schedule.

A La Carte Model: Participants have the option of taking some courses online and some in the classroom [118]. It gives participants more flexibility as they are in charge of their learning experience. Instructors can provide one-to-one support in the classroom or online.

Enriched Virtual Model: A blended learning model where participants have the option of dividing their time revolving around two major components, one as online learning and other as training done via face-to-face mechanism [119]. Participants primarily complete their learning online and come on site for a face-to-face interaction with an instructor on an as-needed basis, instead of scheduled classroom training. Valiathan [120] describes the concept of blend aiming to describe learning or 'intended' learning, also called as skill. Different types of learning falls under his idea such as skill-driven learning, attitude-driven learning, and competency-driven learning. Further, this type of learning is adopted in frameworks like EUT research framework, conceptual framework on learning barrier moderation model, conversational framework, Lewin's cyclical framework after Burns, and Khan's Octagonal Framework and its Variants. The details on different elements used in the framework design in order to maintain the right balance between student's interests with respect to e-learning in higher institutions is described thoroughly with needed case studies. The comparative analysis will be presented thereafter illustrating the advantages and limitations of the above listed models.

Skill based learning: The model is designed to merge two concepts together, one that is accomplished at the student's own speed under the supervision of instructor and another its support in order to improve specific knowledge and skills with bounded timeline. It is a part of traditional classroom training. According to Sellin [121], there is an urgent explicit need for transforming skills gained from training to learning and also from communicating just knowledge given from training to the facilitation of learning. This says that knowledge can be given by more complex interventions, supporting training mixed with other kinds of human development programs. Learning to learn is directly proportional to other approaches including systematic observation, analysis, and a questioning attitude [122]. It also aims to provide students with flexibility with some teacher-directed assistance [123]. It will help in providing a positive correlation between the enhancement of emotional skills and effective teaching. The skill-based learning is infrequent or superficial to participants as it may not recognize the skills that are being fostered through their assignments [124].

Attitude Driven model: This model is a hybrid by considering different activities and interactive platforms to deliver for developing specific behaviors. The meetings or delivery sessions are generally conducted online synchronously. The project works are given to the peers that need to be completed besides working or teaching hours. The simulations are conducted based on the roles [125]. The real problem-solving outcomes are considered through hands-on learning delivered either in a group or in individual sessions [126].

Competency-based learning: This model emphasizes identifying the various competencies needed as different sectors call for varied competencies in general. The various knowledge management resources are merged with performance support tools, supervising to advance in workplace proficiencies. The aim is to make the students get equipped with technical and scientific knowledge depending on different professions and implement skills in varied complex contexts. It is based on the analysis of the professional requirements that will help them to define and prioritize the fundamental competencies required [127]. The learners must interact with and do keen observation to be in line with the experts in order to make a comparison with their skills and competencies required to fulfill their commitment [128].

EUT driven model: End user training model states to the techniques which emphasize in learning through technology. The training methods given to the participants will enhance their learning abilities and engagement. Much better training results can be seen by combining instructor-led training with e-learning [129]. According to Gupta [130], the pace in changing technology has led to the increased amount of end user training. It helps in coming up with the best practices of institutional strategies. It discusses the various training methods that can prove effective if initiated by specific procedures [130]. The psychology of an individual plays an important role in such type of training methods as to understand the needs and behaviors of specific individuals while engaging them in learning activity [131]. It shows importance to those factor that build and distinguishes individual identity like self-confidence, and support to others [132]. The learning outcomes will depend on the listed factors which can be differentiated by skills, cognitive, affective or meta – cognitive [133].

Conceptual framework on learning barrier: E-learning barriers plays an important role and thus needs attention so that effective e-learning is not disturbed. Andersson and Grönlund [134] presents the extensive summary related to hindrance offered by several e-learning techniques and classified them accordingly into four abstract categories such as Technological, Course related, Individual, and Context related issues. The present domain in the event list with the help of key stakeholders in education field give much clearer view in understanding the barriers affecting the execution of eLearning and altering its success through contextualizing [135]. However, these barriers as stated by Packham et al. [136] if are handled properly by inputting proper control mechanisms, it will not give negative effect, rather will act to enhance the learning experience, further improvising retention [137]. The universities and educational institutes can ensure to use its applicability for engaging students by making different strategies, thus staying in competence and security. The e-learning barriers are those factors that are directly related with diminishing of the students' activities such as limited IT skills, technical problems and learning style associated with the media. Key strategies to manage and overcome these enterprise education barriers would include a realistic recruitment policy, effective induction, recognition of accreditation of prior learning and flexible course structure [138].

Khan's Blended learning: This blending model was proposed by Khan et al. [24][45][139] and is based on eight dimensions reflecting the class of problems that need consideration. It serves as a complete framework for planning, developing, delivering, managing and finally computing the blended learning programs in order to serve a meaningful representation of online learning experience. The eight dimensions are stated as institutional, pedagogical, technological, interface design, evaluation, management, resource support, and ethical [140][141]. The model creates the diverse learning opportunities that technology can provide to the organizations for effective learning by exploring the varied issues and working on the issues for future so that the learning process goes smoothly without any hindrance towards effective delivery of learning. Addressing the issues before hand will surely produce a high return on investment. This notion basically integrates varied communication media. They are developed with an intention to complement one another to enrich learning through hands-on learning by taking analogies and merging diverse applications into it. Online learning must be validated by using different forms of learning tools based on the use of student's ethical behaviors, available resources and technology.

Moderation model: Modelling, conveying and building of knowledge and skills are the three important elements in this model. The communication is done to facilitate human interaction using above listed elements of an e-moderator. This is built on the notion of participant's past experience giving mandatory support and development to participants. They are helped at each stage in order to develop the required expertise in online learning approach. Gilly Salmon's [142] is built on the notion of a five-stage process which helps to involve students through online communication technology. This idea is built on the notion that E-moderators, that are beauty to learning technologies as they are the ones who design and manage activities [143]. The progression of the stages, reflect the continuous interaction and increase in the frequency of individuals for collaborative learning until the return to more individual pursuits begins in the last stage [144]. The students interact with each other and also with the E-moderator, not just sharing information through written material in hardcopy or soft copy.

Table 4 shows the comparative analysis of blended learning models and frameworks discussed above.

B. Tools

It has been surveyed [145] and analyzed that the support sources which are used in order to aid in blended learning are taken from higher educational institutes including universities and colleges. Most of them contracted the online management systems, and among them, the most frequently used systems are Blackboard Learn [146] and Moodle [147]. This has given a varied number of services in terms of communication with peers such as features like chatting, email, pools, discussion groups, clubs, and other events of academics. It was noted that few universities used Second life [148] as an online tool for delivering lectures and uploading course content. Last came those universities in the least category which used English language software in the form of the hard disc (CD ROM, Magnetic Disk). However, the web-based software and open access systems were the once most favored among all adopted by most universities. It has also been analyzed that some of the most renowned universities have taken the utmost use of online blending services by using their online robust systems handled and trained by specialists such as universities of Athabasca, Macquarie, the Open University [UK]. The instructors have been given end-user training on operating these online tools and systems in these universities. Table 5 shows the list of universities and usage of tools.

Table 4: Comparative analysis of blended learning models and frameworks

Model	Type of learning	Features	Technique	Disadvantages	Advantages
Skill-based learning	Traditional classroom learning	Self-paced independent learning	Based on combining self-paced learning with instructor or facilitator support to develop specific knowledge and skills	Method does not suit all students, Lack of regular interaction between students and their peers, Slower students to take longer to complete their studies	Increased flexibility for students and responsibility for their learning, Students become organized, maintain their timetables, develop initiative, Offer more creativity from the teacher's perspective.
Attitude based learning	Web-based learning	Problem-based learning including Hybrid model of activities and interactive platforms	Real problem-solving simulations are described in groups or individually	Need to complete the projects outside normal hours	Hands-on training with simulations for problem-solving desired outcomes
Competence based learning	Individual learning system	A teaching-learning system that combines theory and practice to develop students' anatomy and ability on how to learn.	Focusses more on teaching-learning strategy, modalities, monitoring, and assessment.	Need a certain amount of self-motivation and supervision. The teacher role is modified, needs adapting the university to this transformational change, needs too high commitment. Need type of learning platform for each learning requirement.	It is accepted collectively, students are the drivers of their learning, provides greater enrichment of learning methodologies
EUT driven model	E-learning with single learning delivery medium	Model uses learning and interaction process using training methods	Training model combining Learning techniques and technology	Individual differences need to be considered along with technology; Benefits can be realized only when they can utilize the software properly.	This model is effective for learning because of the lesser number of errors in evaluation features. Greater sense of value. Increased productivity. Flexibility to meet individual's needs.
Conceptual framework on learning barrier	E-learning with single learning delivery medium	Model uses interrelationships with the control mechanisms	Intrinsic and extrinsic factors are used for enhancing the learning process	Student motivation and commitment is affected by both technology and students background, Content delivery, Course structure, and Student perception	Improve retention, Enhance the learning process
Khan's Octagonal Framework	E-learning with multiple learning delivery media	Model combines multiple delivery media based on application-learned behavior	Focusses on delivering the right content following the right content, audience and time.	Combines different Learning approaches and choices become difficult for the students to adapt every time.	Effective delivery of learning, high return on investment, Extending the Reach, Optimizing Development Cost and Time, evidence that Blending Works
Moderation model	Online sequential education is based on a profound education al theory.	The model is based on five stages for the learners to become confident in reflection, assessment and achieve self-actualization.	This follows Maslow's model in blended learning and fulfilling the hierarchy of needs	linear approach and its prescriptive nature, lack of flexibility to accommodate new ideas, individual learning styles not considered, rigid application of the 5 Stage Mode	A practical approach of learning, Learners become responsible for their learning, self-actualization is built which is difficult with other forms of learning, good student support, compatible with working life

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Table 5: Comparative Analysis of Tools used at Various Universities

Universities	LMS	Moodle	Blackboard	CD ROM	Independent learning systems
The Open University, UK					Yes
Universidad Nacional de Colombia, Colombia	Yes				
Universidad de La Sabana, Colombia			Yes		
Athabasca University, Canada		Yes			
University of Illinois at Chicago, USA			Yes		
University of Calgary, Canada			Yes		
Macquarie University, Australia					Yes
University of New South Wales, Australia					Yes
Open University Malaysia				Yes	
Waseda University, Japan	Yes				
King Faisal University, Saudi Arabia			Yes		
Higher College of University, Dubai, UAE			Yes		
Myanmar Institute of Information Technology (MIIT) Mandalay		Yes			
The Northcap University, India	Yes				
Amity University, India	Yes				
Manav Rachna International University, India	Yes				
Princess Norah Bint Abdulrahman University, Saudi Arabia			Yes		
UAE University, UAE			Yes		

C. How to reduce costs in blended courses?

The intersection of two concepts namely globalization and technology has rapidly changed over the years and because of their continuous growth, it has completely altered our views of education and offering [149]. There has been a persistent rise in which training professionals are often working and explaining new and varied techniques that can benefit the audience with e-learning. Blending learning should fasten by creating awareness by integrating resources to attain a strategic goal such as reducing costs, increasing recurrence of business activities, and reducing time to market [150]. The strategies, in general, are explained which keeps the users focused on strategic advancement concerning blending learning success. The several factors are explained as under:

- **Evaluate learning material (Guidance):** The instructors must facilitate and make the learners aware as they need additional information or resources. To make blended learning an efficient process, guidance is an important tool to aid in the process of achieving success. Learning material must be evaluated for the online format before teaching so as to identify the elements that need consideration in enhancing the content and doing revision so that the content can be uploaded online. The new content should be updated as per the recommendations given in the previous content. These practices will save time and money and make learning efficient [151].
- **Rapid authoring tools (Multidisciplinary aspect):** These online learning tools are also known as the rapid authoring tools, because of their availability, usability, and testability ease. They are predefined formats and other media resources which are user-friendly. The formats provided by these tools can be made as per the need of the organization, enterprise, or company, which does not require time and money as the tools provide a friendly user interface and step-by-step guide manual for reusing the templates. The user need not draw the courses from the beginning rather just customize them and use them as per their need. The people with varied functional expertise must blend towards working across the organization to understand the multidisciplinary goal through complex approaches [152].
- **Designing blended learning (Communication):** A productive asset towards blended learning is providing the right and relevant information to the learners. This is important as it creates an integration between the face-to-face and online environments. The base must be created to design the learning objectives, rather than getting specific to technologies. The learning objectives must be designed along with learner demographics. The use of technology serves to provide the overall conclusion as a crux for building the blended learning strategy. This can be achieved by streamlining the contents with lectures, assessment methods with learning outcomes, and other events and in-class activities that help for providing the most optimal experience in learning [153].
- **Microelement added feature:** Specific short content that is streamlined with narrowed focusing of learning is the most cost-effective online learning solution. The reason is because of its modular approach and multi-device support. This helps in delivering the content as a high pace considering it to develop, rollout, or revising the online available content.
- **Inhouse Vs. Outsourcing (Ensure flexibility):** Encouraging independence by ensuring flexibility is important to make the process go smooth as learning drives the use of technology, rather than the reverse. Outsourcing online learning development means going into the hands of an expert team such as analytics, researchers, and scientists to build the courses in a cost- and time-efficient manner. Inhouse means the instructors in your organization are going to evaluate all the learning outcomes in the same way. A properly developed implementation plan is needed to carry forward the right approach [154][155].
- **Evaluation using a Pilot (Measuring efforts):** testing and debugging are needed as the last checkpoint as an evaluation measure. This is needed to check to test the

technology, instructions, content, activities, and User Experience are working appropriately. The attention of all stakeholders associated with the course delivery mechanism will be attained by realizing the time and cost profits when offered online as visible courses. The offline support tools help in determining which are important and which are not to facilitate learners to have a flawless learning experience. The effectiveness of the session can be improvised by providing relevant feedback to fellow practitioners. Measuring the efforts and sharing the results will help in recognizing it as an opening torrent in the quest for effective blends [156].

V. BLENDED LEARNING PROGRAMS

This section explores blended learning conceptualization, programs and processes followed in recent times. Details are presented as follows.

A. Blended Learning Conceptualizations

This section discusses six different blended learning conceptualizations namely inclusive, quality, quantitative, synchronous, and digital classrooms. Further, enhancing the Blended learning approach through emerging technologies such as 5G communication, IoT, Cloud computing, and Mixed reality are also discussed. Finally, the role of digital badges in the blended learning environment and their effectiveness towards improving the intrinsic motivation of learners are presented.

Inclusive Conceptualization: In blended learning, inclusive conceptualization targets to encompass all the aspects of the teaching-learning process including modalities, methodologies, and enhancement. According to [157], the primary objective of inclusive conceptualization focuses on three concepts namely to encompass the existing different teaching-learning process, to encompass the education management methodologies, and to encompass the different possible scope of the enhancements. Under the teaching, learning modalities include the delivery of the teaching process through conventional chalkboard mode and the technology-based multimedia mode. Here, the inclusive conceptualization targets to combine both the chalkboard mode and digital multimedia mode of instruction modalities. Under the education system methodology includes the conventional offline mode of learning management systems and online mode of the learning management systems. Here, the inclusive conceptualization targets to combine the advantages of both methodologies of learning management systems.

Quality conceptualization: In blending learning, quality conceptualization emphasizes the knowledge quality enrichment by validating positive impacts through robust integration of online and classroom learning modes. Garrison and Kanuka [158] emphasized a hybrid framework of blended learning and technically enriched classroom teaching to achieve robust and feasible quality conceptualization. However, the difficulty in this hybrid model is identified with a very thin line of difference between blended learning and enhanced classroom teaching methods. While each blended learning model depends on several influencing factors, also, each blended learning model may be different from another blended learning. The quality conceptualization in blended learning involves the thoughtful implementation and right amount of quality ensured in hybridizing the classroom teaching and the online learning model.

Quantity conceptualization: In blending learning, the quantity conceptualization addresses the extent of framework to be adapted from two basic teaching modes namely online teaching and classroom teaching. Allen and Seaman [159] discussed that the right quantity of hybridizing portion should be considered in blended learning. The authors suggested that between 30% and 79% of quantification can be required in online teaching for incorporating quantity conceptualization in blended learning. While Bernard et al 2014, suggested for 50% portion of classroom teaching within blended learning in higher education systems. Porter et al. [160] suggested 50% online teaching as a portion in blended learning, while Diep et al. [161] suggested two modes of quantitative blended learning such as 25% online teaching and 50% online teaching.

Synchronous conceptualization: In blended learning, the enrichment of teaching is achieved through technology interventions like real-time video conferences, web-enabled online learning platforms, and interactive learning tools. Hence, the synchronization conceptualization targets to provide the synchrony between the real-world offline teaching model and the virtual learning model. The synchronization focuses on the orientation, flow, and timings between learners, teachers, and peers during the entire blended learning process. According to [162], the various learning tasks such as problem-solving, group discussions, class interaction, collaborated learning must be synchronized in the blended learning model. Another dimension to synchronization involves various types of electronic devices and mediums used for the teaching-learning process. According to [163], the learning medium that involves electronic gadgets such as laptops, notepads, personal computers, iPad, much also be synchronized to support the entire blended learning process model.

Digital Classroom Conceptualization: In blended learning, the digital classroom conceptualization targets to provide concrete integration of Information and communication technology (ICT) into the teaching-learning model. Although blended learning in itself encompasses a digital medium of instructions, the several factors such as given below need to be approached in efficient ways.

- What learning stage this digitization should be incorporated?
- What are modes of digital classroom teaching?
- How to evaluate the learning process through digital conceptualization?
- What proportion of digitization should be considered?

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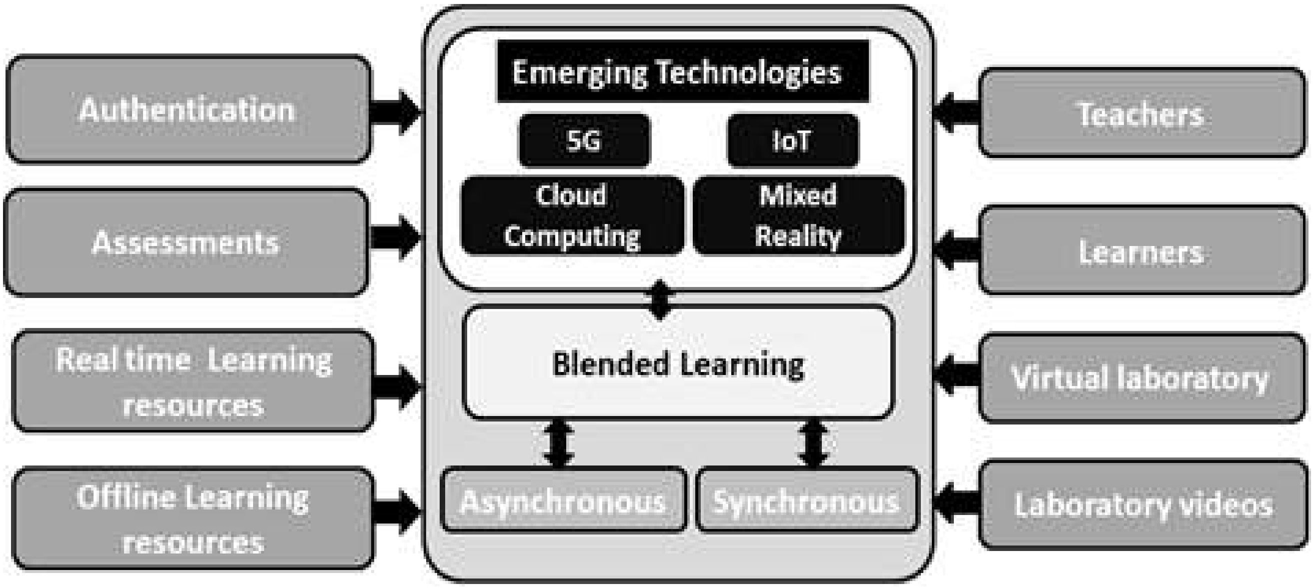

Figure 5: Basic framework of blended learning components associating with emerging technologies

In [164]-[166], authors studied the concept of digital classroom on K-12 grade students. Similarly, Jou et al. [165] studied the digital classroom conceptualization in blended learning for higher education level. The comprehensive study on the digital medium of studying using laptop, table and desktop computers was conducted by the Smith and Suzuki [166]. While, Cakir & Bichelmeyer [164] conducted the comprehensive study on the usage of paper-based studying materials and online study materials at K-12 school students.

B. Processes of eLearning and Blended Learning Adopted in Past and Present

The present scenario and future of blended learning is expected to be dominated by the integration of emerging technologies such as Internet of things (IoT), 5G mobile communication, cloud computing, and mixed reality. Figure 5 depicts the basic framework of blended learning components and associated emerging technologies. Armando et al. [73] discussed about the concept of 5GOpenClass for the technology era of 2020 and future that enhances the blended learning model. 5GOpenClass incorporates high-definition video streaming, Internet of things (IoT) as part of teaching learning process, where the teacher and learners can perform live streaming of class videos, multimedia-based learning materials repository, interactive live video chats, and whiteboards. The authors have developed a 5G enable product for blended learning environment.

Ever and Rajan [167] addressed the incorporation of emerging technologies into higher education model like medical science. The outcome of this study reveals that the 5G enabled blended learning as the top priority for medicine learner community as it provides efficient interactive live environment for learning. Zhonmei et al. [168] addressed the long-distance learning method through 5G and IoT enabled learning environment. The study involves higher education courses that require both theoretical materials and practical learning environment. The effectiveness of blended learning embedding emerging technologies was analyzed based on factors like connection delay time, download/uploading limits of mixed reality learning materials and network bandwidth consumption. Korobeinikova et al. [169] and Ma et al. [170] study the effect of Cloud based teaching learning model at University level education. The cloud based self-learning -work environment for university level subjects enables learners with essential learning materials and virtual activities for higher level professional courses and trainings.

Mixed Reality (MR) includes several fusion techniques for amalgamation of real-world entities and the virtual world entities. Most common fusion technique involves Virtual Reality (VR) and Augmented Reality (AR). In the VR technique, the computer generates simulation of a completely virtual world and its entities. The users in VR are capable of interacting with various virtual entities through sensor based electronic devices such as specialized gloves, joysticks and goggles. In the AR technique, the real-world environment is blended and enhanced along with virtual entities. The commonly used blending tools include use of virtual visual entities, sound effects or sensory stimulus is incorporated through enhanced computer-based AR technology. Tang et al. [171] studied the effect of using MR in the university students. The primary objective was to compare the conventional instructional methods and the MR based learning for design subjects. The performance was measured based on the geometric design analysis level and creativity level within the learners.

C. Blended Digital Badge Programs

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According to [172], at the university level, a major section of the learner population under blended learning is either already holding employment or are adult persons. It is observed that, in this scenario, under blended learning at the university level, the motivation level of learners is lowered over time. Major reasons for low motivation include distraction from external factors and virtual tasks with a low level of interactive student activities. This necessitates enhancing the instructional and learning strategies that focus to increase student's motivation level to complete their virtual tasks. One such solution is to adapt a gamification strategy for instructional and learning modality in the blended learning environment. The gamification strategy involves rewards, improvement indicators, feedback, and reviews. In recent years, the use of digital badges for online blended learning is popularly adopted by many online university courses. In 2011, Mozilla Firefox introduced the Open Badge standard. Subsequently, the second version of Open Badge was updated in 2018. The Open Badges are digital recognitions that characterize the significant achievements of participants in the digitized visual manner [173].

The objective of the use of digital badges for blended learning includes analysis of learners' state of mind towards the utilization of digital badges and correlation between the digital badges and the learners' performance. First, analysis of learner's state of mind towards the utilization of digital badge involves the characteristics of learners themselves. Such characteristic of the learners includes the high expectation of learners and improved level of learner's attitude towards obtaining a digital badge. Secondly, the learner's performance measurement in terms of correlation includes the rate of acceptance, satisfaction level of learning, participation in class interaction and timely completion of virtual tasks. According to studies [174][175], the digital badges motivated the students to effectively understand the concepts of the subjects, improve their confidence level, able to complete the learning outcomes, and gain competency in the subjects.

VI. MOBILE BLENDED LEARNING

This section explores mobile-based blended learning experiences. Details are presented as follows.

A. Models for Mobile blended learning

Advanced mobile devices and innovations in communication technologies begin to transform everyday peoples' lives and cultures. The use of smartphones and other portable devices has now been applied to education, which has led to the advancement of mobile learning (m-learning) at diverse scales. Mobile learning is gaining prominence as it alters the traditional concept of teaching and learning using handheld devices. To overcome the established shortcomings of mobile learning while retaining its truly revolutionary value for the use of mobile technology in higher education, initiatives are taken to integrate it with main curriculum. Blended learning has long tried to tie combined traditional classroom and online learning. Overall, when you realize the individual advantages of both, it seems stupid not to use them in a single, structured educational process. Even though mobile learning has taken place, all of the obstacles for an effective blended learning environment have vanished. Contemporary handheld devices are stronger than they have ever been, and they are filled with all sorts of gadgets that can put together several learning strategies. Blended learning seeks to strike the perfect balance between face-to-face and online training methodologies. It also blends well with the concept of a "flipped classroom" [176]. The proliferation of mobile Internet has streamlined the conventional online learning model, and learning can shift out of the classroom to a greater extent. University frameworks have their origins in formal higher education institutions, where courses have been taught by the teachers in synchronous seminar formats. Originally, blended learning was used to supplement these synchronous lectures by using asynchronous conversation boards and learning management systems (LMS) such as Blackboard and Moodle.

a) **Mobile blended learning system Based on Moodle LMS**

Moodle stands for Modular Object-Oriented Dynamic Learning Environment, which is one of the most widely used Learning Management Systems (LMS) and is available as an open-source tool. Moodle aids various universities and institutes in managing the e-courses using the concept of mobile blended learning. This tool is very helpful for various educators and instructors to create the course content to deliver the online lectures in both synchronous and asynchronous modes. Moreover, it also facilitates the learners/students in tracking their performance, and learn new things with the aid of several multimedia tools. Moodle LMS provides various features and functionalities that make mobile blended learning more effective. Some of the features are as follows:

- Allow the instructors to develop the reusable study material using various technologies like multimedia, handle the online evaluation and assessment, collaborate and connect with students synchronously and asynchronously, and involve students in learning experiences.
- Include a versatile teaching-learning interface for 24 X 7 connectivity. Learning opportunities and events and promoting learning outside the classroom.
- Check the English Language proficiency of the pupils.
- Engaging learners in self-study, social learning, self-assessment, and critical analysis.
- Push reminders and updates to students via e-mail and the Moodle smartphone app.
- Besides, it enables students' access to study material developed by faculty.

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Table 6: Mobile blended learning tools and platforms

Key Features / Mobile Blended Learning apps	Platforms Supported			Key Features							Integrations			
	Web based	iPhone app	Android app	Windows Phone app	API	Activity Dashboard	Assignment Management	Asynchronous	Assessment Management	Automatic Notifications	Facebook	LinkedIn	Google Calendar	GoTo Meeting
Violet LMS	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	Y	N	N
Canvas LMS	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	N	N
Courseplay	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y
Talent LMS	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
SAP Litmos	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	N

b) **Mobile blended learning system Based on Blackboard**

The Blackboard is a tool that helps in managing online learning in a virtual class environment. It is framed to work as a virtual learning space for students and instructors where they can communicate, share their work with progress, and can be evaluated based on certain tests and assignments. There are various benefits of mobile blended learning using blackboard, some of them are mentioned below:

- The live lectures can be recorded and can be watched later for future reference. Therefore, there is no opportunity to miss any classes and/or the content delivered.
- It enables students to one on one attention after class timings where students can clear their doubts and can discuss future projects.
- It allows students of different domains and classrooms to collaborate and work together on various projects and assignments. This feature helps them to share their interdisciplinary ideas, help them to flourish, and nourish technically without any boundaries.
- The feature of sharing video and audio during online lectures makes the experience more realistic and thus leads to good interactivity.
- It also facilitates students to track their past performances based on their grades in quizzes and tests and the students can access the study material 24*7 without any problem. This provides the availability of course content and study materials to the students.
- Such online learning platforms help the educational institutes in reducing their printing costs and thus helps in protecting the environment by providing the content digitally.
- The students can revise their courses multiple times, helping them in securing good grades and learning new things easily.

B. Tools, Techniques, Methods, and Models for Mobile Blended Learning

Blended learning is the agglomeration of multiple learning methods. Blended learning in the modern curriculum model applies to the use of technologies to improve the instructional process by incorporating the lessons taught in the classroom. Learners in all learning environments are conscious of mixed learning. What this consists of depends n on the opportunities, rules, and interests of the student. An interface that is best suited for mixed learning intends to make learning smooth through time and space. This smooth experience is important when evaluating learning flow and behavioral needs. A study by the Pew Research Center in 2018 showed that 77% of Americans own smartphones. This is a drastic improvement from their first survey in 2011, which showed that 35 percent of Americans owned mobile phones. Besides, the authors Hamm, Drysdale, and Moore, in their book on mobile pedagogy, express that "people expect to be able to perform life tasks—work, study, and play all the time and everywhere" [177]. There are various tools/platforms related to mobile blended learning, the popular ones are discussed in Table 6.

C. Impacts of WhatsApp and similar mobile Applications in Education

In universities and higher education institutions, there is a need to boost web experiences and create awareness between students through mobiles. This is possible through mobile-based personnel contacts, synchronous or asynchronous learning modes including instant messaging, mobile social networks, internet-based applications for communications, and use of smart devices. Mobile learning

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technologies use a wide range of mobile devices, including Mp3 players, smartphones, mobile telephones, iPads, iPods, iPhones, tablets, and many more. Smart devices provide students with connectivity and interactivity. Mobile learning is about support for an increasingly mobile population from diverse culture, colleges, and organizations. WhatsApp Instant Messaging is a mobile cross-platform messaging where users use their current Internet data plan to help socially communicate in real-time. WhatsApp gives online users a range of media including photographs, video, and audio media messages to upload and receive. For Apple iOS, Google Android, Blackberry OS, and Microsoft Windows tablets, client software is available, among others. Figure 6 shows the integration of WhatsApp and similar mobile applications in mobile blended learning. The WhatsApp-like apps can be integrated with Mobile-based Blended Learning Systems to make things easier for learners and teachers. Various functionalities are provided when the mobile blended learning moves to such type of integration. In [177], It gives educators standardized, simple, and extensible solutions. At the same time, teachers will also improve and broaden the capabilities of the Mobile Blended Learning Framework through the open interface.

In [178], based on the findings, the researchers encourage smartphone teachers and actors only to try WhatsApp mobile applications in a mixed direction, involving both face-to-face and mobile learning. The study findings indicate that WhatsApp is a good platform for mobile learning when used in a comprehensive curriculum approach. In a consolidated mobile lecture, an intimate, in-class discussion of the completion of the courses is favored for mobile applications such as WhatsApp. In [179], Early on, it is clear how the WhatsApp application can affect learning, which plays a vital role in children's everyday life and holds the characteristics to be regarded as a social network. The analysis concludes that the application has a positive effect on the success and its use is highly accepted. One should not neglect the capacity of WhatsApp technology to contribute to education as a supporting framework through natural education technology and its capability. In [180], Instant texting from WhatsApp is an

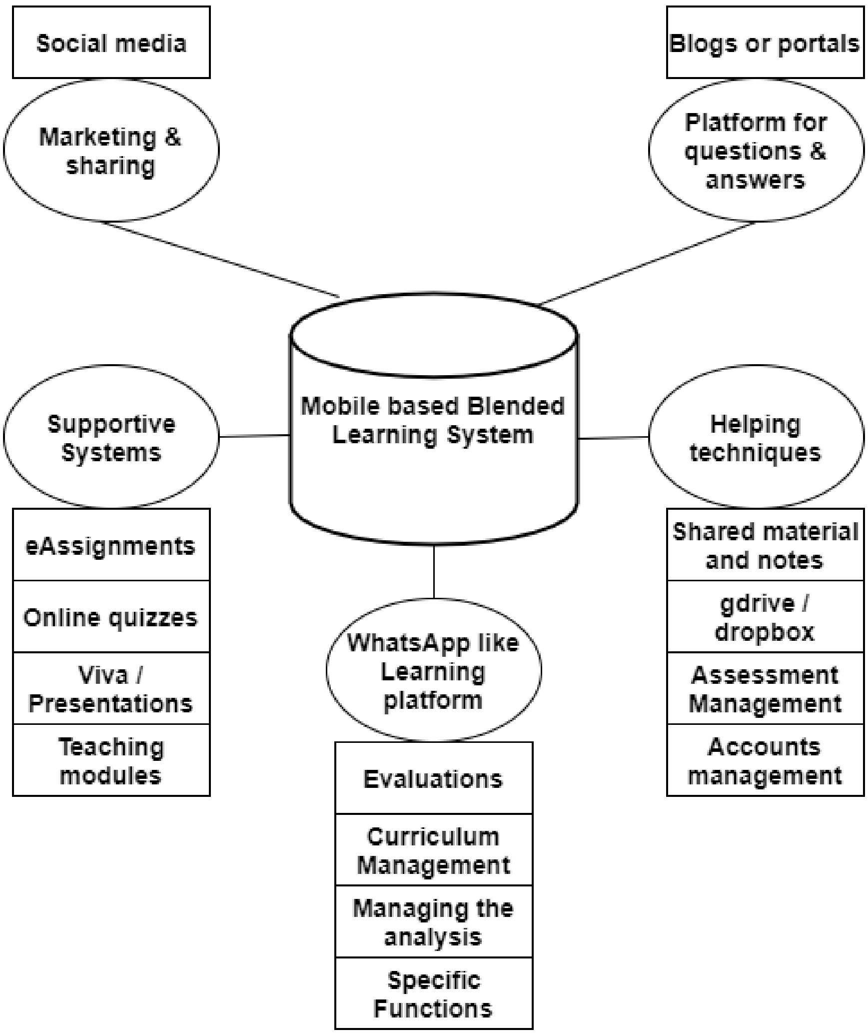

Figure 6: Integrating WhatsApp like apps with Mobile Blended Learning System

advantageous and free program. SMS from the mobile device helps the user to synchronize and accept messages. It is quick, intuitive, and easy to use WhatsApp Instant Messaging Framework. Users will speak more with mates without slowing down the system. Another feature of WhatsApp Instant Messaging is that it helps people, to move all addresses, from the address book. Many related programs require their telephone number from users without the contacts ever being moved.

D. Context-Aware and Contextualized Mobile Learning

The context is defined as the student state, the condition of the education activity, the state of the facilities, and the state of the environment. The measurements of each of these states are then further defined. To understand, evaluate each dimension concerning its variables. Of course, the more precise the model gets, however complex, the more knowledge is available about each aspect. Context-aware computation [181] is becoming an attempt to find intelligent interfaces between humans and mobile computing. Mobile systems and sensor technology converge to include mobile apps with spatial and environmental contexts. While this area of research currently dominates location and destination applications, many illuminated works expand the importance of meaning into abstract context from the positions and other physical sensor details. Context-awareness is not a recent idea of learning but has also been at the forefront of the computer-supported learning industry. To include learners in their environment and their ability to develop new awareness while studying, context adaptation techniques are essential. Suitable context change techniques may be incorporated into pedagogical methods such as active social learning; problem-oriented learning training, alternate schedules, etc. In [182], it has been observed that while a large number of proposals covering context-aware training programs from different viewpoints and some proposals report more changes to apprenticeships, there are still substantial restrictions on context-aware apprenticeship systems in this area. In [183], it reflects on "context" as a theory in education design. Many models of curriculum design do not regard context or regard context as a passive factor that shapes learning materials. More sensors and actuators are available and embedded in mobile technologies and the Internet of things asks for a passive context-awareness. Concepts such as smooth learning highlight a new framework for learning and instructional concepts. In [184], creation and growth in the area of color representation and display technology, promote a combined learning concept for an engineering course. For the effectiveness of the teaching case, an effective learning environment is critical. The paper's key subject is a combination of academic presentations, practical applications, and experimentation with the benefits of new digital technology. In [185], suggests an updated blended form of learning as well as a case report on its application to building automation engineering education in a university of technology. A new organizational framework with the tools and strategies of successful distance learning implemented during COVID-19 lock-down will be addressed in this updated process. Finally, there are many perspectives, general observations, and the recognition of students' favorite ways of distance learning. In [186], the information obtained in the two categories for analysis, a quantitative analysis was carried out. The results have given the reversed learning experience a positive impression, especially in terms of overall satisfaction. Besides, the participants commented on the simple use of mobile devices and stressed the value of a suitable video content design for a good, rotated learning experience through mobile devices. Additional study is required because the students have already been presented with project difficulties. In [187], the suggested framework aims at promoting the learning process, addressing student needs and enabling the dialogue and cooperation between students and professors, and fostering university students' co-operative scenario-driven learning. The proposed "Easy-Edu" was constructed with an agile approach that offers sustainable and high-quality mobile learning. Unlike other conventional systems. It also removes the risk of total device failure, detects, and solves bugs more easily. In [188], the results of this research confirm the efficacy of the mobile app in the study of new terms and phrases that is consistent with other research on this subject. The use of the applications in casual environments enhances the social environment of students and increases the academic ability of students. It is also necessary to assess if the progress rate is improved with time for students who use the smartphone app while studying. In [112], the present research illustrates how mixed learning can be strengthened using location based mobile learning environments as teaching is enhanced by approaches based on Media Learning Experience theory (MLE). The conclusions revealed that the transaction distances and hence the outcomes were smaller for those trained for MLE-principles. Gender and thought gaps were also discovered and the need for more adaptive teaching methods to be adapted in mobile learning settings was stressed.

VII. BLENDED LEARNING EXPERIENCES

This section explains the online, blended, or hybrid learning practices applied in two universities: (i) University of Petroleum and Energy Studies (UPES), Dehradun, India, and (ii) Jaypee Institute of Information Technology, Noida, India. Details are presented as follows.

A. Blended Learning Practices in University of Petroleum and Energy Studies

This section explains the online, blended, or hybrid learning practices applied in computer science education at graduate, post-graduate, and doctoral-level studies, especially during COVID-19 times. The details of online, blended or hybrid learning practices in course design, theory and laboratory courses, and minor and major project handling are explained as follows.

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a) **Blended Learning and Professional Development in Course Design**

This section explains the Postgraduate Certificate in Academic Practice (PGCAP) practices followed to train the teachers in course design preparation, and advanced ways of teaching in engineering education. Figure 7 explains the PGCAP modules and detailed processes followed for training the new teachers (having experience of less than 3-years) for blended learning using Blackboard, Codetantra, and Mettle. The PGCAP program has four modules: module-1 to module-4. The detailed module-wise explanations are as follows.

Module-1: This is an important module. According to this module, every mentee (new teacher or a teacher selected for the PGCAP program for training) must attend a special training session (delivered by assigned Mentor) and selected classroom sessions of Mentor as well. Additionally, every mentee attends classes of other mentees and observes their style of teaching a class. This is a four-week activity and thereafter, feedback of every mentee is filled by other mentees and mentors.

Module-2: In this module, each teacher is given a new course and asked to design the course plans, lecture delivery details, program outcomes, program-specific outcomes, course outcomes, and evaluation components using Bloom's taxonomy. This course is executed for a semester and every Mentor constantly monitors his/her assigned Mentee's performance. Student feedback is an important component in module-2 evaluation. In case of successful performance, the student can proceed to module-3. Whereas, Mentee has to repeat module-2 in case of unsuccessful performance.

Module-3: In this module, Blackboard, Codetantra, and Mettle software are used for blended learning. An international faculty and industry guest speakers are invited to have digital devices-based online teaching. International faculty evaluates mentees for their digital devices-based blended learning module.

Module-4: Every Mentee, who has cleared module-1 to module-3, must write an article statimg their findings in this PGCAP program, over experimentation in their courses, and evaluations. Mentor and research department support is always available for improving the quality of the article, software support for plagiarism checks, grammar corrections, diagram/figures drawing, and Latex. PGCAP certificate is awarded to Mentees provided his/her article is published in some peer-reviewed reputed journal.

In UPES, Blended and online learning programs are executed for the last 6 years. This program runs for various theory, laboratory, and project courses. Details of these programs are discussed in subsequent sections.

b) **Tools and Techniques Used by Teachers in Handling Theory Courses Using Blended Learning**

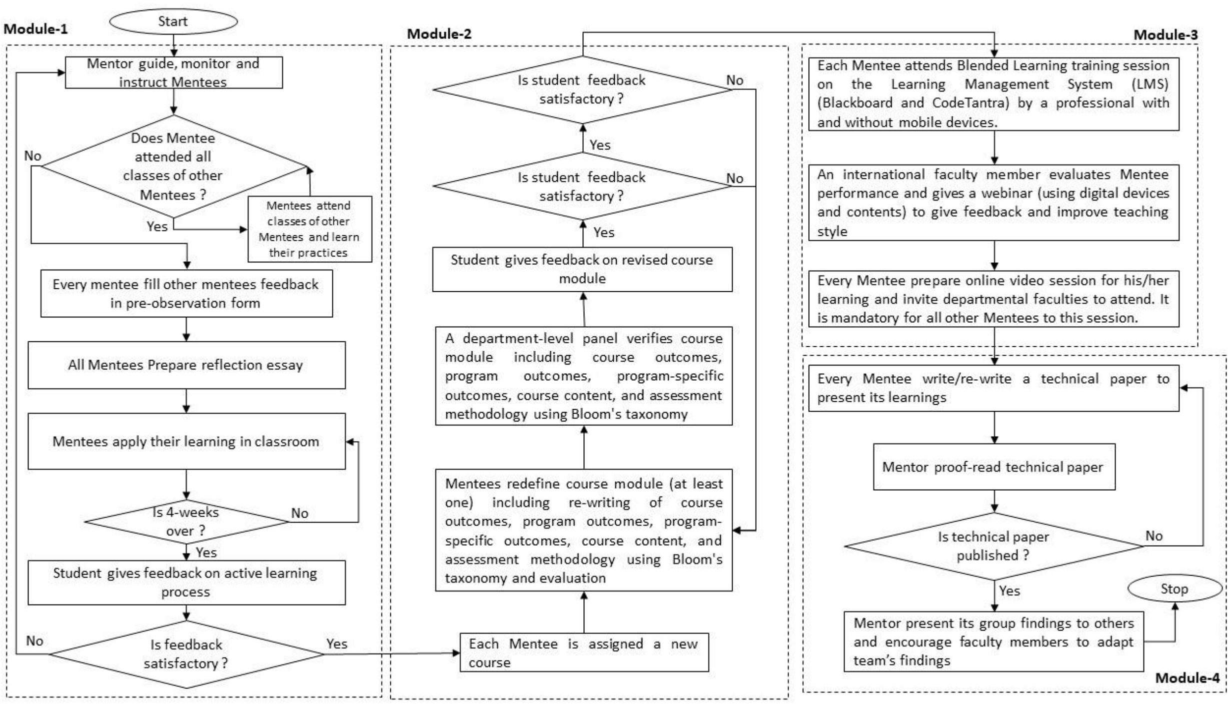

Figure 7: New Teacher's Training Process for Blended Learning Process Implementation in UPES Courses

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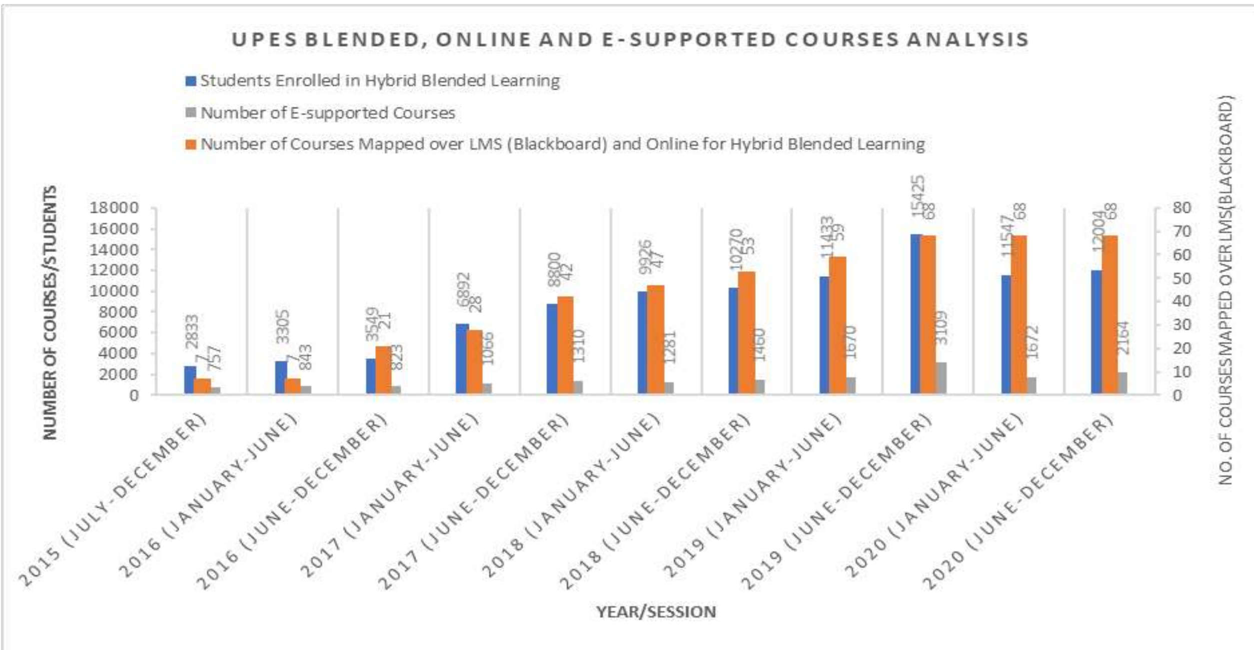

Figure 8: Comparative analysis of UPES Blended, Online, and E-supported Courses.

From UPES management's point of view, the needs of the millennial students are different, and it varies from time to time. Further, the use of digital ways and means to learn and assimilate the knowledge is preferred in a well-connected and collaborative environment. It has been observed in university practices that the digital way of learning is interesting and important for technical content seekers and information-hungry students, and they prefer to learn via visual learning approaches which give preference to on-demand training sessions. Thus, UPES introduced hybrid, blended and online pedagogical elements into their traditional way of the academic delivery system. In 2015, UPES introduced the Blended and Online Learning model in their academic system based on the recommendation of IQAC (Internal Quality Assurance Cell). Since 2015, various courses are running either in blended, online, or e-supported mode. Figure 8 shows the detailed analysis of students' enrolments in hybrid blended learning courses, e-supported courses, and the number of courses mapped over the LMS system, (Blackboard) and online for hybrid blended learning. This analysis is performed with variations in sessions over multiple years. Results show that student's interest and enrolment is increasing in blended learning in the past 6 years. However, a maximum enrolment is observed in the year 2019 (June to December semester) for 68 LMS mapped courses and 3109 e-supported courses.

Online and Video Lecture Preparation for Theory Courses: In UPES, online and video lectures were prepared during Blended and Online learning practices using two tools Kaltura- (integrated within Blackboard) and OBS Studio (https://obsproject.com/). In UPES, a Hybrid, Blended, and Online (HBO) learning department is part of the Learning Development Center (LDC) that plans and manages all resources and activities related to hybrid, blended or online experiences. HBO department floated the option to provide technical support to Kaltura and OBS Studio platform. This support includes software installation (with the support of the IT-Department), training on how to prepare audio/video lectures, directions to prepare lectures for handicapped and needful students, tracking the number of views and per student view, and other material like study material (with the support of library). Using the Blackboard platform (https://learn.upes.ac.in), it was possible to keep tracking and prepare a record of every theory course teaching activity like automated student attendance and marking, faculty attendance as per his/her teaching time table, creating lecture repositories, assignment submission, conducting quizzes, preparing marks sheet in grade center, making one to one or group discussions, making announcements, sending emails, creating study groups, collecting student submissions, usage of LockDown browsers and many more. In conclusion, it has been observed that Blackboard is found to be a very useful tool during the last 6 years especially during COVID-19 times when there was a strong need to implement all of the theory course teachings in an online mode.

Online Examination Module for Theory Courses: Figure 9 and Figure 10 shows the online examination process followed during COVID-19 period using Codetantra for theory courses. Figure 11 shows the complete process in detail. This process is explained through the following phases:

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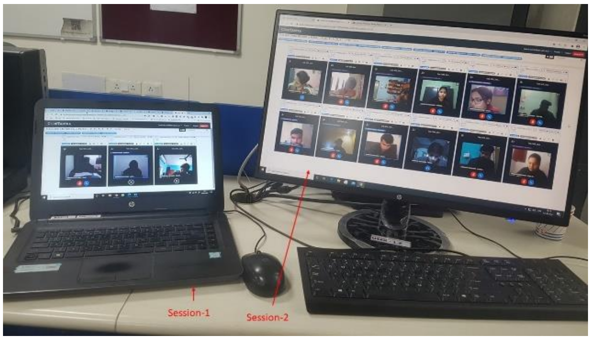

Figure 9: Multi-Session proctoring using Codetantra

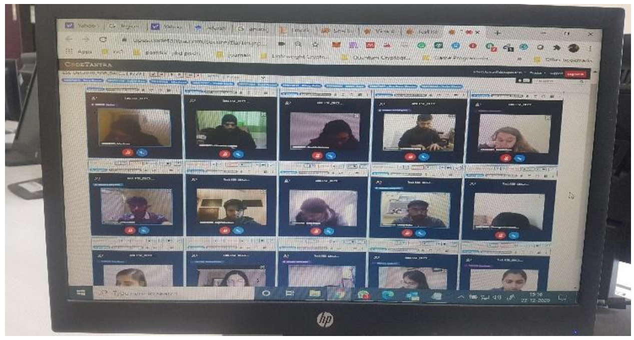

Figure 10: Single/Merged-Session proctoring using Codetantra

- ***Initial Setup Phase*****:** This is an initial phase to set up the environment for examination. In this setup, the proctor has to login into the codetantra software 45 minutes before the start of the examination at a dedicated place in university premises. This place has all the necessary setup for audio and video aids. A student has to login into the system 30 minutes before the start of the examination. Proctor verifies student's credentials and instructs them to sit in a hassle-free environment. In this examination system, the student has an option to have the text and audio-based chat with proctor whereas, a proctor can see the students live, make text or audio-based chat, block a student if his/her activities are suspicious, make general or specific observations, broadcast or unicast text or audio messages,
- Proctor Unsuccessful Reporting: A case is considered in proctor unsuccessful reporting if the proctor faces hardware or software issues, emergency conditions, internet issues or other issues like attending important meetings then the proctor has to report to their super proctor (SP) (a senior faculty member incharge of 15 to 20 proctors) or Student Record and Examination (SRE) center. In such cases, the SP or SRE center has to make an alternative proctor arrangement.
- Proctor Successful Reporting: In case of successful reporting, the proctor will continuously monitor students, their environment (360o), and activities. This is a continuous three hours' process where the proctor, SP, and SRE department work in collaboration to make online examination successful. In this activity, every proctor has to monitor 30 students (maximum), every SP has to monitor 15 to 20 proctors, and the SRE center monitors all SPs. In a successful case, it is assumed that all activities started and ended on-time without any technical or administration interruption.
- SP Successful Reporting: As discussed earlier, a SP has to monitor 15 to 20 proctors for three hours of examination duty. Every SP has to perform 10 to 15 examination duties for completing 12000+ students' online exams. In successful SP reporting, it has been assumed that no proctor reported him/her any technical or administrative issue, and there is no need to report to SRE center for redoing or extending any exam activity.
- **SP Unsuccessful Reporting**: In case of SP unsuccessful reporting, technical and administrative challenges are expected to come. This may be due to bad weather, emergency conditions, or urgent work. Such issues at any level can cause internet disruption, technical glitches, or unsuccessful monitoring.
- **SRE Team**: This is a university-level central committee that monitors all examination and student records-related activities. Among these activities, online examination is one of the important activities. During COVID-19 period, it has been observed that this center was actively involved in purchasing the software (in association with the university's management team), training the teaching and non-teaching staff, preparing teachers as a proctors, and SP, preparing non-teaching staff for handling technical issues, training the examiners to perform various online activities like evaluating the answer sheets, assigning marks, preparing a list of marks as per course objectives and program objectives, perform online grading, and so on. The SRE department repeats online examination activities for supplementary and special supplementary exams as well. This department ensures that every teaching and non-teaching staff member should be involved in these activities, and there should be a uniform distribution of duties among all.

c) **Tools and Techniques Used by Teachers in Handling Laboratory Courses Using Blended Learning**

During COVID-19 times, it has been observed that handling laboratory courses were a major challenging task. To assign laboratory exercises, monitor, and evaluate the student Blackboard platform

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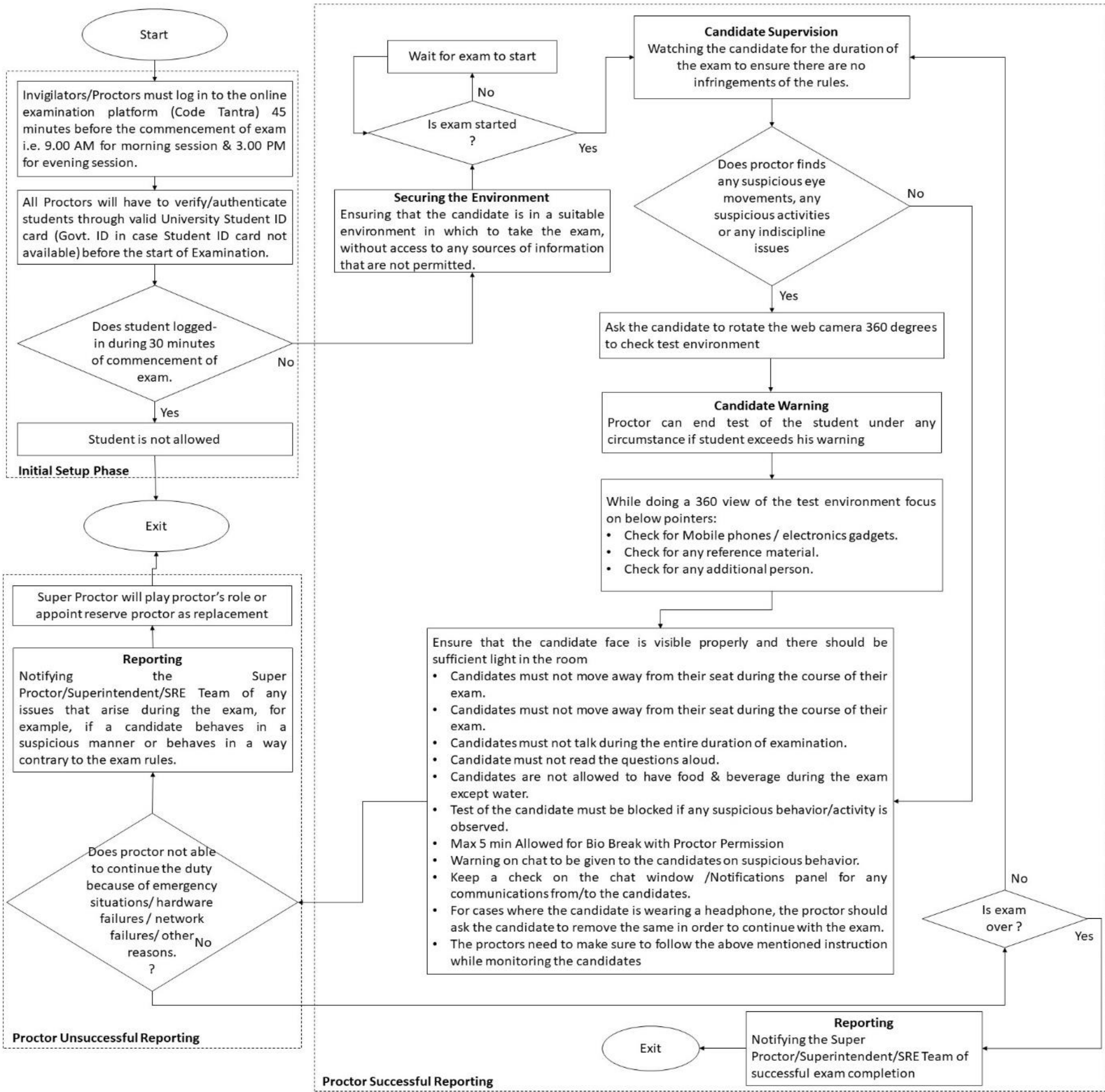

Figure 11: Online examination process followed during COVID-19 timing using Codetantra for theory courses.

(https://learn.upes.ac.in/) was used in UPES. However, various engineering courses were handled differently. Following is a brief explanation of laboratory-related activities following during COVID-19 times in Blended and Online Learning mode. Figure 12 shows the activities and their sequence in detail.

- In mechanical, chemical, physics, and electronic courses, a laboratory faculty prepared a video recording of experimentation and shared it with students over Blackboard. This video recording was made available to the student throughout the semester and assignments were given to students to complete it within the specified time. In this practice, if a student can repeat experimentation within their home environment, then he/she can share the video and audio recording of it or opt for mathematical or theoretical answering mode.
- For computer science courses, E-Lab software (http://elab.in/) was made available to students and faculty members were to create a laboratory environment in one place. There were many accessories and library packages arranged for different courses. Using this platform, students were able to prepare their experimentations and submit assignment reports. A faculty member was able to monitor student daily activities, evaluate the students and prepare a marks sheet.

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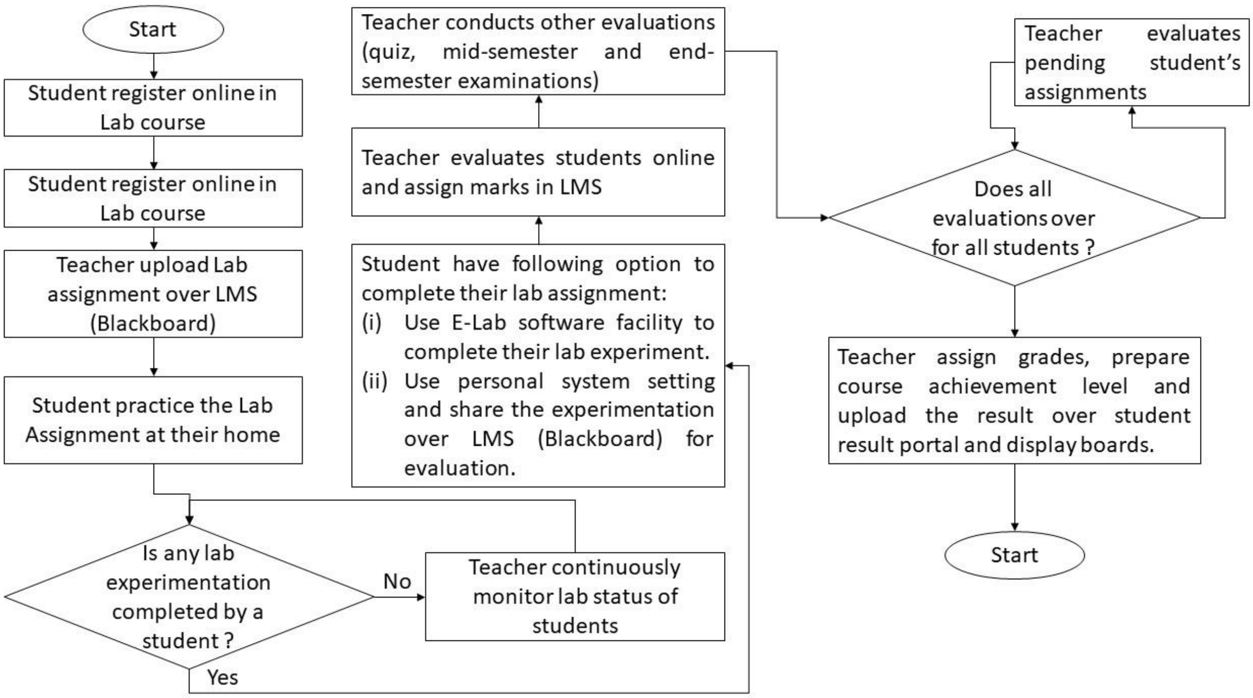

Figure 12: Online examination process followed during COVID-19 timing using Blackboard for laboratory courses.

- Many teachers have been given the option to use virtualization software and share virtualization images with faculty. This option was much convenient to faculty members in creating repositories and evaluate the student according to the environment that the student set up to execute his/her experimentation. This practice is found to be more flawless compared to other approaches.
- Some of the faculty members have used platforms like Zoom, Gsuite, JioMeet, and other meeting software for face-to-face interactions with students and to carry out their evaluation. This practice is least preferred as there were data security and privacy issues, and students were not able to show-up their experimentation in a way that they were interested in.

d) **Minor and Major Project Handling Practices Using Blended Learning Tools**

The minor and major projects at UPES are hosted on Blackboard platform. The entire process is carried out on the mobile blended learning mode and is explained below in Figure 13. Minor and major project evaluations were also having similar challenges as those in laboratory experimentation. In minor and major project evaluation following laboratory practices were repeated.

- The majority of project evaluations were performed over the Blackboard platform. However, very few evaluations were conducted over Zoom, G Suite, and Jio Meet Platforms. An alternative platform was selected in those cases when technical challenges were faced.
- Faculty and students were given an option to use the E-Lab software facility to make their project work available in one place and conducted all activities smoothly.
- The project mentor and evaluation panel were given the rights to collect virtualization images of students and execute them during the evaluation process. This is found to be a preferred approach as both parties (examinee and examiner) were able to prove their claims.

B. Blended Learning Practices in JIIT

This section presents the blended learning experiences at JIIT, Noida, India. Details are presented as follows.

a) **Blended Learning and Professional Development in Course Design**

This section discusses about the blended learning and professional development model adapted in Jaypee Institute of Information Technology, Noida. Here, the tools and techniques involved in three different aspect of teaching methodology is discussed namely (i) IoT analytics as theory course, (ii) IoT systems Lab as practical course, and (iii) project.

i. **Objective of blended learning**

The objectives and effects of blended learning models towards teaching the students in this internet era has been discussed by several research works in literature [189][190]. Yigit et al. [191] discussed about the blended learning for the computer science and engineering field. In summary, the two major objectives of blended learning include (I) support to faculty teaching and (ii) Facilitate students to learn. The first objective, support to faculty teaching aims to provide support to faculty teaching various

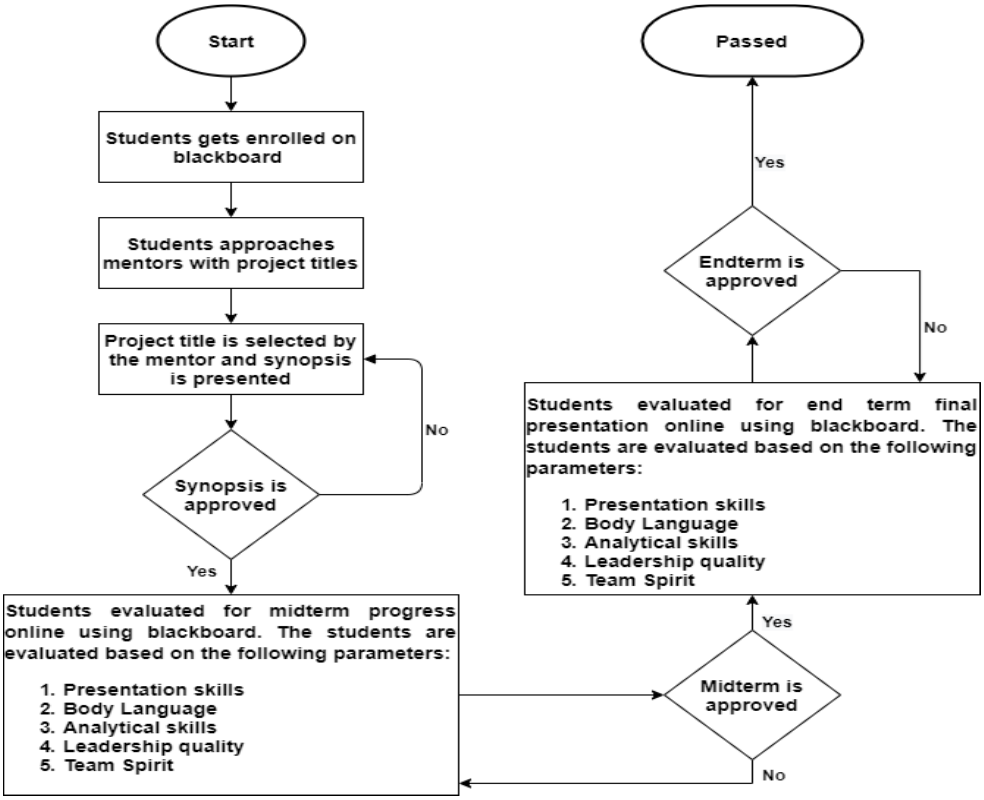

Figure 13: Minor and Major Project Handling Practices using blackboard.

courses in the university. The guidelines and recommendations are provided to the faculty to handle online mechanism and blended tool usage and also to handle interaction with the classes. Second objective, facilitate students to learn, targets to provide support to students and allow students to take advantage of the HEI resources and excel in the courses. Such facility provides students to enhance their soft skill such as writing, communication and presentation. The support for students are provided by the continuity institute academic online platforms such as websites.

b) **Tools and Techniques Used by Teachers in Handling Theory Courses Using Blended Learning**

The active learning methodology allows students from different learning levels to carry tasks on their own and enables them to reflect on the specific tasks. Particularly, the various effects of using blended learning approach to teach computer programming under influence factors like diverse culture, motivating factors and the role of pervasive computing techniques were explored by authors in [5][192][193]. In fact, teaching different subject with in the thrust areas of computer science were discussed in [194]-[196]. Authors in [197][198] elaborated the various motivational factors and effect of teaching in flipped classroom methods and learning management systems. Authors in [198] proposed the explanatory visualization (EVF) framework. In this framework, three different stages with six learning parts based on active learning was proposed. The three consecutive stages focused on the learner's ability to develop learning strategies based on lecture materials, practical experiments, intermediately assessment and continuous performance feedback. The six components of EVF are research, report, design alternatives, plan, develop and reflect. The framework targeted on students to develop creative thinking in which students had to create visualizations for explanation purpose based on visualization algorithms and computer graphics. The hybrid of active learning and blended learning has been studied by authors in [199]-[201], helps to envision the methodology of teaching in future perspective.

According to authors in [202], during COVID 19 pandemic, at institution level, it commonly followed hybrid, blended learning and active learning mechanisms. Based on our experience, here we propose stage-wise blended active learning (SW-BAL model) that consists of active learning process integrated with existing blended learning model. In addition, as part of active learning, the students are allowed to opt for flexible credit inclusion through four different online learning platforms National Programme on Technology Enhanced Learning (NPTEL) after prior permission from competent university authority. Further, as part of blended learning, throughout the COVID pandemic, the classes were taken using various online meeting platforms such as Google classroom, zoom meeting, Microsoft Teams and Cisco WebEx. Authors in [203]-[205] explored the wide range of accomplishments for blended

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learning through concepts like card-based toolkit, visual interfacing, and sketching designs. Further, the enhanced active learning methodologies were addressed by authors in [205]-[211] that targeted on factors like learning environment, student's feedback, human behavior, computer-based assessment tools and mobile based active learning.

Our proposed framework SW-BAL consists of three stage process based on Blooms' taxonomy outcomes. Table 7 depicts the various components of proposed SW-BAL model. Further, the credits transfer is incorporated for preapproved recognized online learning courses, to facilitate the student's interest on expertise learning. Here, each stage is decided based on the intermediate evaluation process and feedback mechanism. Our framework consists of three stages with three assessment mechanisms.

All three components of teaching methodology namely lecture, tutorial, and practical session were carried out in online platform based blended learning model. At undergraduate engineering degree level, for a class strength of 30 students, each instructor will interact with students in stipulated time period of 3 contact hours for lecture, 1 hour for tutorial and 2 hours of practical sessions per week. Also, during each stage of learning, the stage wise assessment of individual students was conducted through online mode. Figure 14 depicts use of various online learning and meeting platforms for Stage-wise Blended Active learning.

The feedback regarding online teaching mode was taken from a sample size of 120 students from undergrad engineering students. The Figure 15 depicts the Likert scale in the range of 5 to 1, where 5 indicates excellent and 1 indicates poor rating. Figure 15 depicts students' feedback based on stage wise blended active learning through online mode.

Table 7: Components of stage wise blended active learning model

Stage #1	Assessment for Stage #1	Stage #2	Assessment for Stage #1	Stage #3	Assessment for Stage #3
Understanding concepts	• Comprehensive Test • Multiple Choice Questions • Synopsis Mini project • Feedback to students	Analyse Concepts	• Comprehensive Test • Multiple Choice Questions • Mid evaluation of Mini project • Feedback to students	Analyse & apply concepts	Direct Assessment • Written Test • Multiple Choice Questions • Final evaluation of Mini project Indirect Assessment • Attendance • Class performance • Day2Day activities
Basic Problem Solving		Enhanced Problem Solving		Enhanced Problem Solving	
Team work based problem formulation		Team work based design solution		Team work implementation of solution	

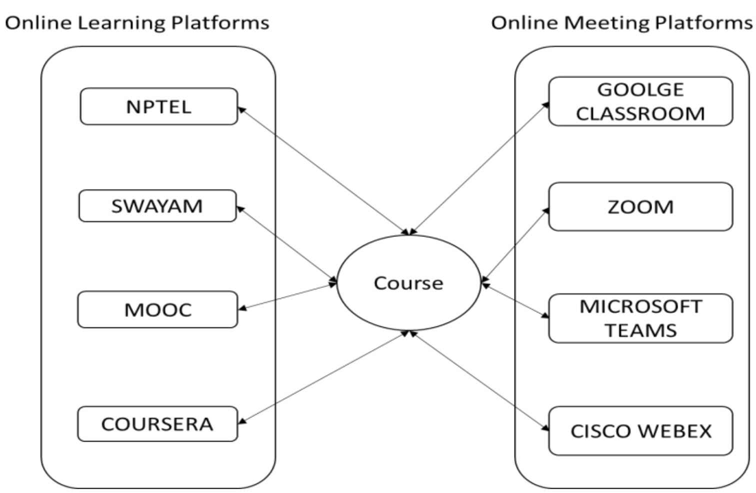

Figure 14: Various online learning and meeting platform used for Stage wise Blended Active learning.

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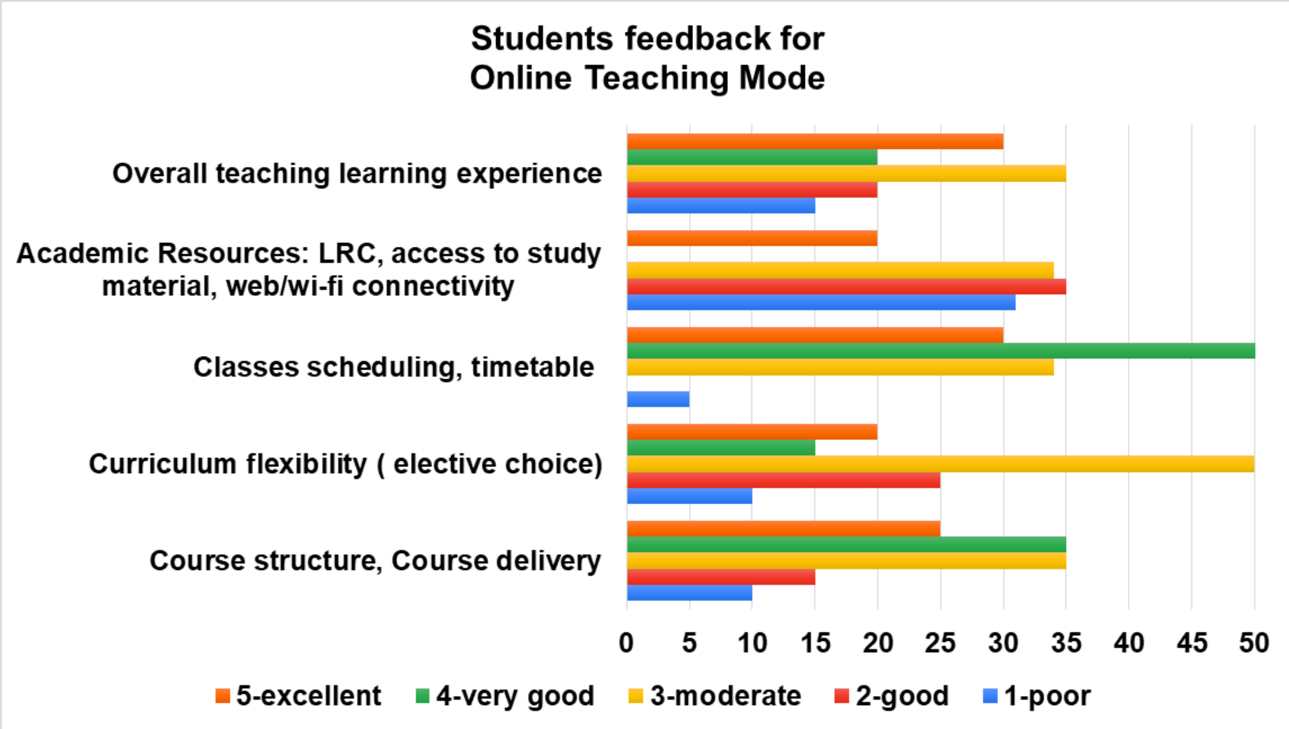

Figure 15: Student's feedback based on stage-wise blended active learning through online mode.

i. IoT Analytics based on stage-wise blended active learning approach

Authors in [212]-[214] explored the opportunities of developing online mode course content on topics such as signal processing, mobile computing, IoT, etc. This section discusses a case study based on the SW-BAL model for the theory course namely "IoT Analytics". This course involves the study of data analysis mechanism and tools to extract the knowledgeable information from the voluminous data gathered from the enormous interconnected Internet of Things smart devices [215]. The IoT analytics influences a wide variety of applications such as Industrial IoT, smart city, smart healthcare, smart environment, smart transportation, smart agriculture, smart meters, etc. It is to be noted that, IoT analytics is considered as a subcategory under the Big Data concept, as such, the IoT analytics handles heterogeneous data streams that need to be processed, combined, and evaluated for extracting knowledgeable information. The global market towards IoT Analytics is envisaged to grow at 31% of the Compound Annual Growth Rate (CAGR) by 2022 [216]. Hence, the higher education institution is in a strong urge to inculcate skills and career acumen for the engineering graduates towards the field of IoT and related IoT analytics.

The course IoT Analytics is offered by the department of computer science as an elective for the students of the seventh semester for fourth-year undergraduate students. The course was open for students of Computer science (CS) and Information Technology (IT). For the academic year of 2019-2020, a total of 120 students opted for this course. The course was conducted completely on an online meeting platform through Google Classroom. As per the active learning part, the contact hours of the IoT Analytics course were provided as 3 hours of lecturing, 1 hour of the tutorial. The IoT Data Analytics course primarily focuses on five modules namely (i) Introduction to data analytics for IoT, Machine Learning (ii) IoT & Big data (iii) Edge and Fog computing (iv) Network analysis (v) Web-enhanced IoT. Under the first module namely "Introduction to data analytics for IoT", the concepts such as Structured versus Unstructured Data, understanding of Data in Motion versus Data at Rest, IoT analytics overview, challenges, and in-depth Machine learning and Deep learning for IoT analytics were covered. The second module focuses on getting Intelligence from IoT Big Data, IoT Predictive Analytics; Geographical Concepts and Spatial Technology for IoT; big data Platform for IoT Analytics, massively parallel processing databases such as Hadoop Ecosystem, Lambda Architecture- NoSQL Databases, Cloud-based Amazon web services, Azure Data Lake and IoT Hub, Node-RED were focuses. The focus of third module, Edge and Fog Computing, is on the Architecture of Edge and Fog Computing, edge Analytics Core Functions, the various Distributed Analytics Systems, and Fog Computing. The fourth module focuses on Flexible NetFlow Architecture and components, the Flexible NetFlow in Multiservice IoT Networks and IoT Network Analytics. Finally, the fifth module focuses on Web-enhanced IoT such as Design layers and their complexity, the Web-Enhanced Building Automation Systems with case study on Smart City Control and Monitoring. Figure 16 depicts the flow of conducting IoT analytic courses based on the proposed SW-BAL model.

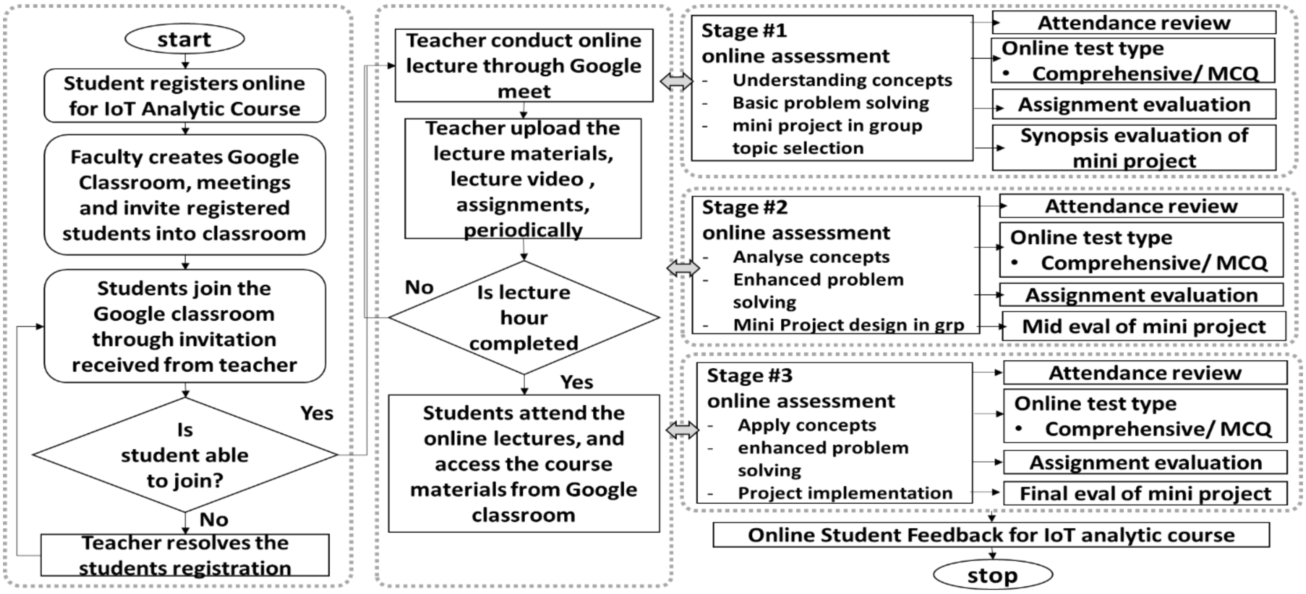

Figure 16: Flow diagram of conducting IoT analytic course based on the proposed SW-BAL model

Table 8: The mapping of IoT analytics course outcomes with cognitive level of Bloom taxonomy.

COURSE OUTCOMES		COGNITIVE LEVELS
CO1	Understand how analytics relates to IoT data	Understand Level (Level 2)
C02	Apply appropriate machine learning, Deep Learning algorithms to gain business insights from IoT data.	Apply Level (Level 3)
C03	Analyse various big data platforms and massively parallel processing databases for IoT systems	Analyse Level (level 4)
C04	Examine how streaming and predictive analytics can be used for IoT Data processing and analysis, in real time.	Apply Level (Level 3)
C05	Understand the concept of network flow analytics using Flexible NetFlow in IoT systems.	Understand Level (Level 2)
C06	Evaluate the performance of the overall system and security in IoT network.	Evaluate Level (level 5)
C07	Design methods and develop web based IoT applications using big data analytics for real world problems	Create Level (Level 6)

Course Outcomes mapped to the Blooms' taxonomy is as described below for the IoT analytics course. There were total seven course outcomes and are mapped to the different cognitive levels of Blooms' taxonomy as depicted in Table 8.

The feedback of the students enrolled under the IoT analytics elective is obtained at the end of the course. The consolidated result of students' feedback is depicted by the Figure 17. It is observed that more than 80% of students responded with rating greater than 3 for all the seven course outcomes. Hence, it implies that the IoT Analytics course was quite useful and interesting from the perspective of students.

c) **Tools and Techniques Used by Teachers in Handling Laboratory Courses Using Blended Learning**

The IoT Systems lab was based on the visual programming concept. It is essential for the learners to understand the actual functionalities within the IoT systems. From literature, it is evident that, visual based programming is efficient methodology for the learners to understand the underlying programming complexities [217]. The SenseBoard hardware based IoT laboratory course was discussed by authors in [218]. The SenseBoard programming environment is different from other conventional method. It uses visual programming concept for developing coding and applications engineering skill with in the learner. Due to COVID 19 pandemic lockdown, the laboratory based on real hardware equipment's of IoT devices were not possible. On the other hand, teachers have to meet the requirement to enable the inculcation of IoT concepts in students. To overcome this, the IoT system lab was conducted through virtual programming mode. NodeRED platform provides integrated development environment through the concepts of virtual programming model. NodeRED is operational both on the desktop standalone environment and cloud-based programming environment. Figure 18 depicts the graphical user interface of the NodeRED platform.

Upon this virtual programming environment, the proposed Stage-wise Blended Active Learning was incorporated. The IoT systems lab was conducted for 2 hours each week, for a

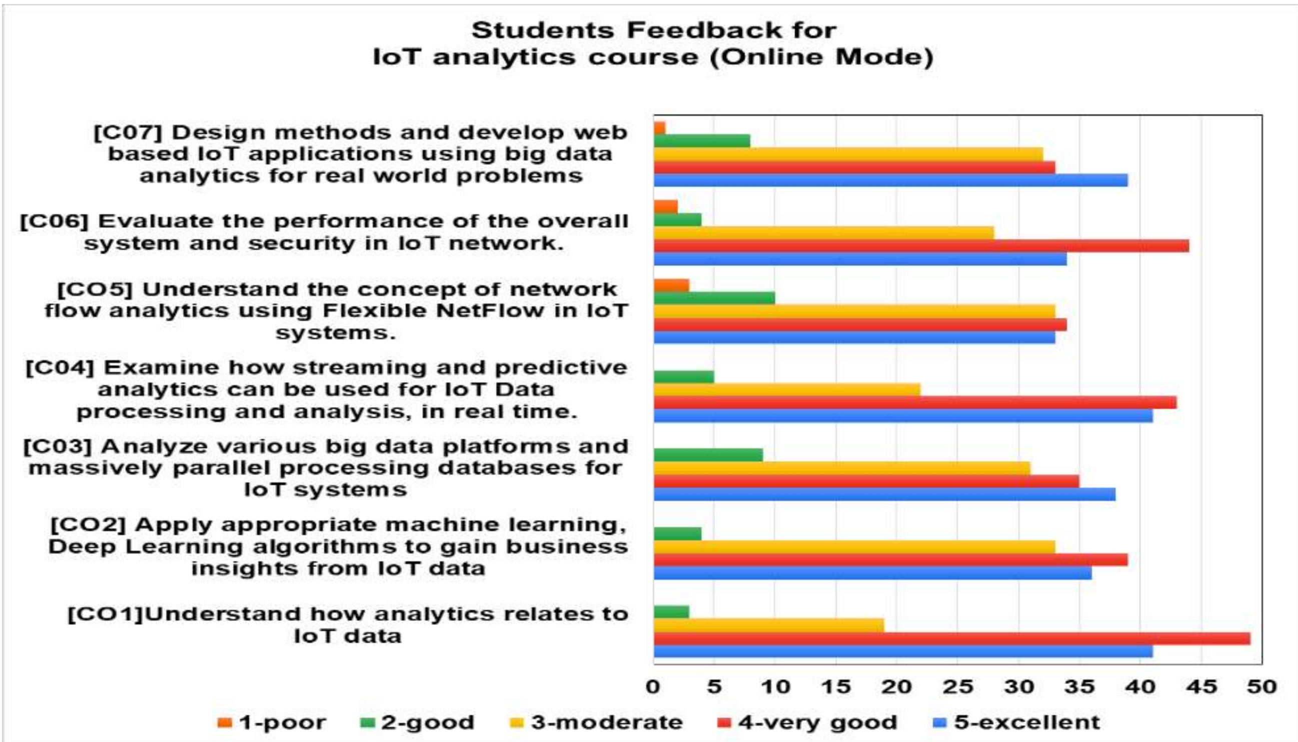

Figure 17: Students feedback based on course outcomes in proposed online model.

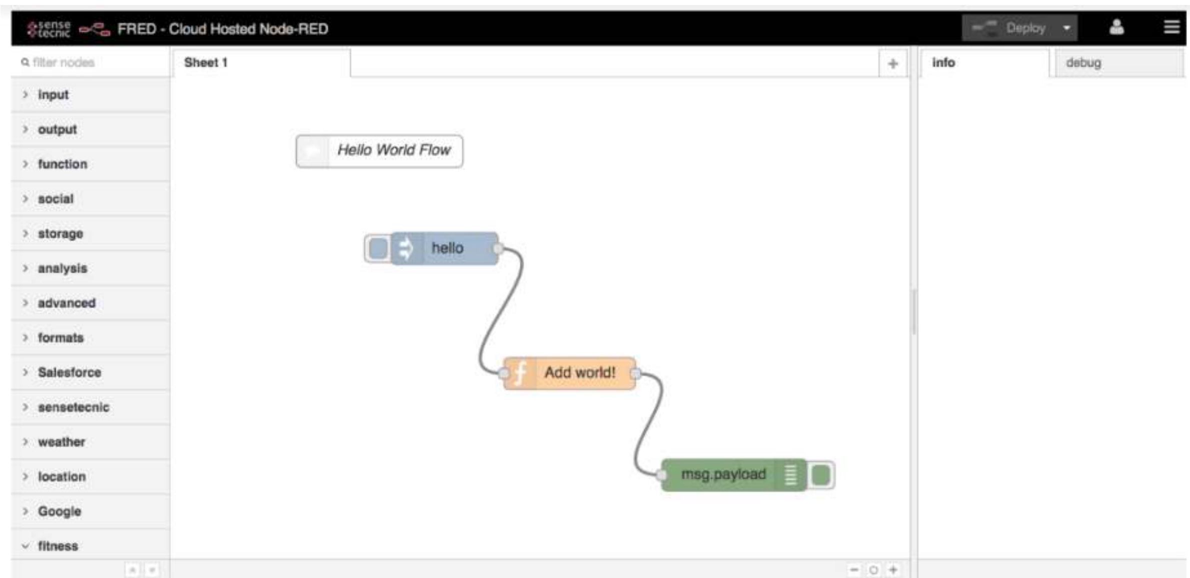

Figure 18: Graphic interface for NodeRED platform

total of 13 weeks. Each of the laboratory exercises are associated with an active learning approach. In this sense, the practical questions were designed in such a way that the learning ability of students is stirred up in terms of problem analysis, and solution synthesis. Figure 19 depicts a sample exercise assigned to the students for the IoT systems lab in virtual programming mode.

The IoT systems lab based on a virtual programming environment was conducted using the Google Classroom platform. Each week laboratory exercises were posted on the classroom platform. Further, the proposed SW-BAT model was followed throughout the semester. The screenshots of the Google Classroom for learning material, resource repository and the assessment processes are depicted in Figure 20 below.

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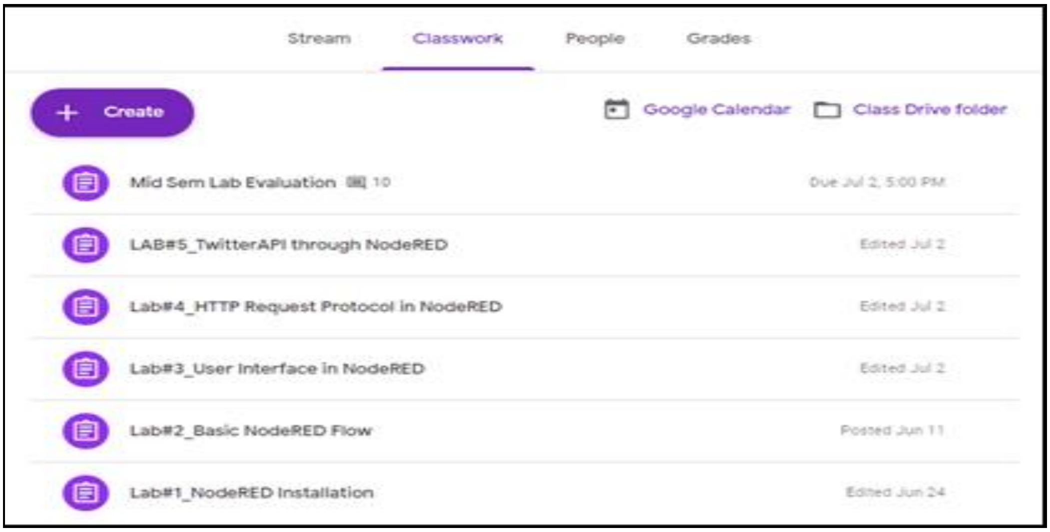
<u>Sample exercise:</u>
Q1) Create NodeRED Flow, to check when the temperature is
(i) Greater than 35 then send "VERY HOT TEMP" message into your tweet account
(ii) Less than 12 then send "COLD TEMP" message into your tweet account
(iii) Between 12 to 25 then send "PLEASANT TEMP" message into your tweet account
Q2) Create NodeRED Flow, to display the gauge node according to the temperature received through your input node
Q3) Create NodeRED Flow, using appropriate User Interfaces to develop an "AUTOMATIC WEATHER REPORTING" application.

Figure 19: Sample exercise for IoT Systems lab



(a) Learning resources for IoT system lab on Google classroom

(b) Online assessment for IoT system lab on Google classroom

Figure 20: Google classroom interface for the IoT systems Lab course

d) **Minor and Major Project Handling Practices Using Blended Learning Tools**

This session discusses the project work offered through the blended learning method for undergraduate engineering students under the Department of Computer Science and Information Technology. A total 389 students and a group size of 3-4 students were considered. The students are allowed to choose their project area that suits their interests based on the knowledge they acquired through their learning process. Figure 21 depicts the pie chart for various thrust areas for the project opted by students.

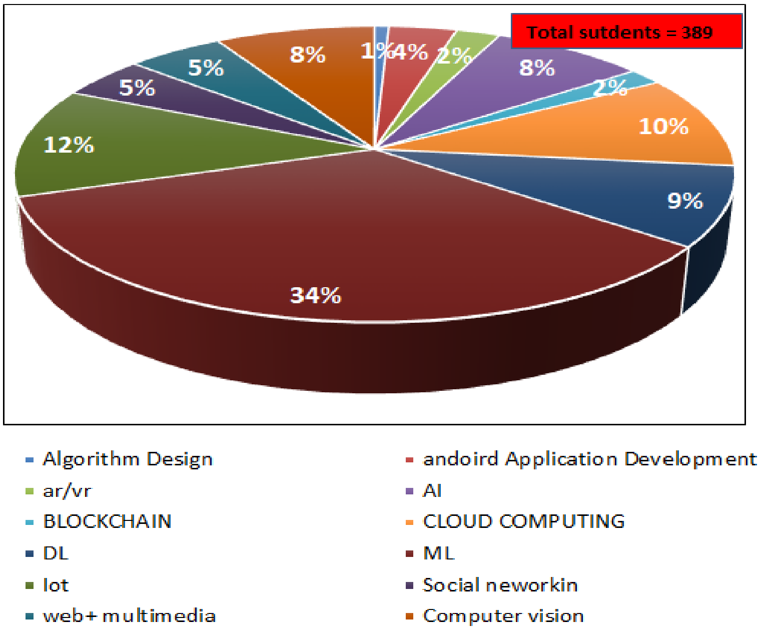


Figure 21: Pie chart for various thrust area for the project opted by students.

The three-stage evaluation of the project was observed. The evaluation was conducted with objectives namely (i) Panel assessment (ii) Day-2-day activities of students (iii) mentoring of junior students and (iv) term paper writing. Each evaluation strategy focuses on emphasizing and measuring the level of active learning gained by the students. Evaluation stages are monitored by panel members comprising of 2-3 expertise faculty members in the thrust area. The panel assessment is based on evaluation criteria such as (i) quality of the survey, quality of related research papers and other resources (ii) identification of research gap (iii) reporting quality in a prescribed standardized format with diagram, and comparative tables (iv) presentation and exhibit of work in terms of student's confidence, depth of content, and communication skills. Next, the day today activities of students was monitored through (i) regularity and frequency of meeting with supervisor (ii) solution identification, analysis and evaluation of the performance in term of Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. Next, the mentoring of junior students through interaction and lending guidance for junior semester students. And finally, the students have to write a term paper that presents a detailed reflection of the project work carried out. The term paper must be of good quality and reflect the problem targeted, the solution proposed, the methodology adopted, experimentation, results and discussion, and also conclusion with future scope.

VIII. DISCUSSIONS AND FINDINGS

In this article, we outlined the recent trends of blended learning tools, programs, and the author's experiences. These experiences discuss the "blends" of face-to-face and e-learning practices in schools as well as in high education institutes. The comparative analysis of blended learning types, mobile blended learning platforms, and real-time blended learning experiences, observed during COVID-19 times, are discussed in this work. The objective of studying blended learning practices, performing comparative analysis, and analyzing the real-time experimentation is to evaluate the need and impact of blended learning approaches effective during past, present (COVID-19 time), and future.

In our finding, it has been observed that blended learning approaches (mobile, web, or digital devices-based blended learning) are effective compared to traditional e-learning or face-to-face learning. This effectiveness can be observed using improvement in student's performance, increasing student's interest, high-level cognitive processing, more concentration towards individual student's requirements, and fulfill the demands of present times (COVID-19). Here, student's performance is related to student's academic achievements, and results. Student's interests include student's participation in classroom activities. High-level cognitive processing includes increasing student's learning abilities and in-depth conceptual knowledge. In recent times, various initiatives have been taken to promote Blended and Online learning practices worldwide. Most of these approaches are effective in different environments. However, there are still many limitations of Blended and Online learning-based experiences. Some of these limitations are discussed as follows [4].

- ***Lack of Automation***: It has been observed that current Blended learning practices require a lot of human interventions. In addition to course work/material preparation, a teacher has to prepare in-depth Blended learning strategies for their courses by considering individual student requirements. An effective approach will be to develop an automated Blended learning platform (web, mobile, or desktop) that reduces the teacher's efforts and provides provision to both teacher and student to opt for the platform as per their needs and importance. This way of implementing Blended learning experiences would be time-saving for faculty and students that can be utilized in improving the quality of teaching and course-material preparation.

- ***Lack of large-scale Blended learning experiences and surveys***: It has been observed that Blended learning is widely adopted in reputed universities worldwide. However, these in-depth experiences are not shared in the form of publications for promoting them to other growing places. Further, a large number of published studies are the individual experiences in implementing Blended learning to an individual or few courses. A detailed study of implementing it to a discipline over a long period is required for others to go through it in detail, understand the nitty-gritty, modify as per the availability of resources, and adopt.
- ***Lack of resources and managerial decision power***: To successfully implement the Blended, Hybrid, or Online learning practices, official approvals/permissions are required from individual organization's higher management to implement it at a large scale. Sometimes, this approval is required to implement it on a small scale as well. These approvals are required because such learning practices require tools and techniques. To overcome this challenge, developing open-source or freeware platforms would be an effective approach. Such a platform can give every individual faculty, the rights, to implement it at a small scale in his/her environment, learning from their own experiences, and continuously improve and integrate it at a large scale. Most of the existing and good quality software is commercial and it is difficult for developing country's management or faculty to adopt it in its present form due to financial constraints.
- ***Lack of security and privacy concerns***: With the increase in usage and importance of Blended learning practices, tools, and techniques, a large number of users (students and faculty members) get associated with it. This platform stores the user's and course data as well. Lack of data security surveys and observations can lower the importance of these platforms. Usage of modern security frameworks in Blended learning tools is important to ensure user data, course-related activities (exam, quiz, puzzle, assignment), and organizational integrity.
- ***Lack of Internet access and Technology***: In [4], it has been observed that a large part of geographical region is still not having proper/stable internet connectivity and technologies necessary to successfully execute the Blended and Online learning programs. Ensuring infrastructure and providing technologies can solve a large number of learning challenges. All this is possible with transparent and strong federal government's policy decisions of every country.

Likewise, there are various challenges in present blended learning tools, practices, and processes. Additionally, open-source e-learning and online platforms ensuring data security and privacy are required to be developed such that it would be possible for every developing country to make some standardized blended learning processes, and education can be made available to everyone.

IX. CONCLUSIONS AND FUTURE DIRECTIONS

The use of technology-enhanced learning environments such as blended learning practices is found to be effective in pandemic situations. Blended learning supports both synchronous and asynchronous modes of learning in online or face-to-face learning processes. This article has prepared a detailed survey of blended learning practices, tools, and techniques used in different education systems. Here, a comparative analysis of existing blended learning practices is also conducted to identify their importance in different domains. In blended learning, there are various types of learning models. These models and their characteristics are compared. Further, the real-time analysis of blended learning practices in two Indian universities is explored. These real-time case studies explain the usage of blended learning practices in higher education, especially during pandemic times. Presently, this study is limited to blended learning usage in teaching, examination, and evaluation processes in graduation and post-graduation studies. However, the importance of this learning during recent times suggests that there would be many practical benefits to explore blended learning in different domains including engineering, medical science, technology, mathematics, etc. The literature analysis, comparative studies, and case-study based analysis show that there is a need to do further research in this area. In this research, the short and long-term effects of blended learning in different domains can be explored in detail. Further, those features can be identified and explored that improve the learner and expert's experiences.

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Adarsh Kumar is an Associate Professor in the School of Computer Science with University of Petroleum & Energy Studies, Dehradun, India . He received his Master degree (M. Tech) in Software Engineering from Thapar University, Patiala, Punjab, India and earned his PhD degree from Jaypee Institute of Information Technology University, Noida, India followed by Post-Doc from Software Research Institute, Athlone Institute of Technology, Ireland. From 2005 to 2016, he has been associated with the Department of Computer Science Engineering & Information Technology, Jaypee Institute of Information Technology, Noida, Uttar-Pardesh, India, where he worked as Assistant Professor. His main research interests are cybersecurity, cryptography, network security, and ad-hoc networks. He has many research papers in reputed journals, conferences and workshops. He participated in one European Union H2020 sponsored research project and he is currently executing two research projects sponsored from UPES SEED division and one sponsored from Lancaster University.

RAJALAKSHMI KRISHNAMURTHI (Senior Member, IEEE) received the Ph.D. degree in computer science and engineering from the Department of Computer Science and Engineering, JIIT, Noida, India, in 2016. She is currently an Associated Professor with the Department of Computer Science and Engineering, Jaypee Institute of Information Technology, Noida, India. She has published more than 70 research articles in reputed international journals and conferences. Also, she published several book chapters in CRC Press, Springer, IET and IGI global. She is a Guest Editor Applied Sciences (Springer Nature). Her research interest includes the Internet of Things, applied soft computing, and mobile cloud computing. She is a Technical Program Committee Member and a Reviewer in several international conferences. She is a Professional Member in ACM, SIAM, and CSI.

Surbhi Bhatia is doctorate in Computer Science and Engineering from Banasthali Vidypaith, India. She earned Project management Professional Certification from reputed Project Management Institute, USA. She is currently an Assistant Professor in Department of Information Systems, College of Computer Sciences and Information Technology, King Faisal University, Saudi Arabia. She has more than 8 years of teaching and academic experience. She is the Editorial board member with Inderscience Publishers in the International Journal of Hybrid Intelligence and in SN Applied Sciences, Springer. She has been granted national and international patents. She has published papers in reputed journals and conferences in high indexing databases. She is also serving as a guest editor of special issues in reputed journals of Springer and Elsevier. She has delivered talks as keynote speaker in IEEE conferences and in faculty development programs. She has successfully authored and edited 7 books from Springer, Wiley, Elsevier and Springer. She has completed the funded research projects granted from Deanship of Scientific Research at King Faisal University and also from Ministry of Education, Saudi Arabia. Her research interests are Machine Learning, Data Mining and Sentiment Analysis. ORCHID: 0000-0003-3097-6568

Keshav Kaushik is an Assistant Professor in the Department of Systemics, School of Computer Science at the University of Petroleum and Energy Studies, Dehradun, India. He is pursuing a Ph.D. in Cybersecurity and Forensics. He is an experienced educator with over 6 years of teaching and research experience in the area of Cybersecurity, the Internet of Things, and Blockchain Technology. Mr. Kaushik received his B.Tech degree in Computer Science and Engineering from the University Institute of Engineering and Technology, Maharshi Dayanand University, Rohtak. In addition, M.Tech degree in Information Technology from YMCA University of Science and Technology, Faridabad, Haryana. He has published several research papers in International Journals and has presented at reputed International Conferences. His research area spans Blockchain Technology, Cybersecurity, and the Internet of Things.

Dr. Neelu Jyothi Ahuja is a Professor and Head-Department of Systemics, at School of Computer Science at University of Petroleum and Energy Studies, Dehradun. Her PhD awarded in 2010, was on development of a prototype rule based expert system for seismic data interpretation. Apart from academic teaching at university level (both at post-graduate and under-graduate levels), she is an active researcher. From period of 2010 to 2017, she has been head of Research Centre-Computing Research Institute, spearheading intra-disciplinary research and coordinating research activities.

She has successfully delivered and is currently executing Government Sponsored R&D Projects, from DST (Department of Science and Technology). She has successfully completed one R&D project funded by Uttarakhand State Council for Science and Technology (UCOST, Dehradun) and two (one from CSRI (Cognitive Science Research Initiative) Division and one from SEED (Science for Equity, Empowerment and Development)) Divisions of DST. Currently she is executing an R&D project sponsored by SEED (Science for Equity, Empowerment and Development) Division of DST under their TIDE (Technology Intervention for Disabled and Elderly). She also holds successful conduction of DST funded consultancies to her credit. Under her supervision, five PhDs have been awarded. Currently, 06 research scholars are undergoing their PhD work under her supervision.

She has been an invited speaker on various technical and research-oriented topics at widely acclaimed forums, both national and international. She is on panel of various committees, including WHO-Promotion of Assistive Products and Technologies, 'DST-Expert Committee for inspection and

On-the-spot review of CORE (long-term) projects'. She has also been a chair at various conference sessions and different internal and external meetings/forums. Her areas of interest include Machine Learning, Intelligent Systems, Intelligent Tutoring Systems, Expert Systems, Artificial Intelligence, ICT, Object oriented development, Programming Languages. She holds 20+ years of experience in teaching, research and project proposal development and has published papers in journals and conferences at international and national level.

Dr. Anand Nayyar received Ph.D (Computer Science) from Desh Bhagat University in 2017 in the area of Wireless Sensor Networks and Swarm Intelligence. He is currently working in Graduate School, Duy Tan University, Da Nang, Vietnam. A Certified Professional with 75+ Professional certificates from CISCO, Microsoft, Oracle, Google, Beingcert, EXIN, GAQM, Cyberoam and many more. Published 450+ Research Papers in various National & International Conferences, International Journals (Scopus/SCI/SCIE/SSCI Indexed) with High Impact Factor. Member of more than 50+ Associations as Senior and Life Member and also acting as ACM Distinguished Speaker. He has authored/co-authored cum Edited 30+ Books of Computer Science. Associated with more than 500 International Conferences as Programme Committee/Chair/Advisory Board/Review Board member. He has 5 Australian Patents to his credit in the area of Wireless Communications, Artificial Intelligence, IoT and Image Processing. He is currently working in the area of Wireless Sensor Networks, IoT, Swarm Intelligence, Cloud Computing, Artificial Intelligence, Blockchain, Cyber Security, Network Simulation and Wireless Communications. Awarded 30+ Awards for Teaching and Research—Young Scientist, Best Scientist, Young Researcher Award, Outstanding Researcher Award, Excellence in Teaching and many more. He is acting as Associate Editor for Wireless Networks (Springer), IET-Quantum Communications, IET Wireless Sensor Systems, IET Networks, IJDST, IJISP, IJCINI. He is acting as Editor-in-Chief of IGI-Global, USA Journal titled "International Journal of Smart Vehicles and Smart Transportation (IJSVST)".

MEHEDI MASUD (Senior Member, IEEE) is a Professor in the Department of Computer Science at the Taif University, Taif, KSA. Dr. Mehedi Masud received his Ph.D. in Computer Science from the University of Ottawa, Canada. His research interests include machine learning, distributed algorithms, data security, formal methods, and health analytics. He has authored and co-authored around 100 publications, including refereed IEEE/ACM/Springer/Elsevier journals, conference papers, books, and book chapters. He has served as a technical program committee member in different international conferences. He is a recipient of many awards, including the Research in Excellence Award from Taif University. He is on the Associate Editorial Board of IEEE Access, International Journal of Knowledge Society Research (IJKSR), and editorial board member of Journal of Software. He also served as a guest editor of ComSIS Journal and Journal of Universal Computer Science (JUCS). Dr. Mehedi is a Senior Member of IEEE, a member of ACM.