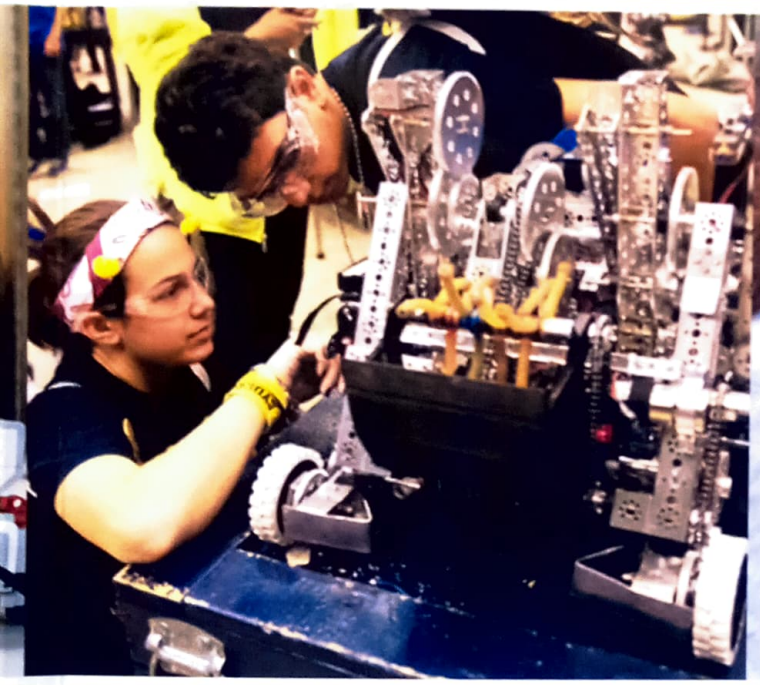
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Editorial





Meena Laad **Ketan Kotecha**

The Internationalization of higher education is one of the significant development trends and is continuously increasing with growing globalization. It is no longer considered a goal in itself but as a means to enhance education quality. Internationalization is fast becoming a crucial agent of change in higher education, in the developed as well as in developing societies. Various efforts have been made to define Internationalization in higher education. Though there exist a diversity of views but a widely known definition of Internationalization is "the process of integrating an international, intercultural, or global dimension into the purpose, functions or delivery of post-secondary education" (Knight, 2008)

The last decade has seen the institutions of higher education, giving prime importance to the Internationalization and putting in serious efforts in this area. The Internationalization of higher education has become one of the most important agendas in the last few years in the majority of institutions in higher education across the world. There have been few compelling factors, which significantly affected the higher education systems worldwide such as growth of a global knowledge economy, the immense broadening in the accessibility to higher education, regular reductions in government's budget for higher education, the advancement in digital technologies, and various ways through which the world is connecting with each other. These factors have significantly affected the traditional roles of higher education institutions at local, national, and international levels. Functioning at an international higher education background brings a critical impact on the missions and plans for developing and implementing higher education institutions in the globalized society (Guri-Rosenblit, 2015). The employability readiness, skills, and competencies are top levers which propel to scale the value chain and optimize the capacity building of their human resource. (Yeravdekar, V. R., & Tiwari, G., 2014).

According to UNESCO's position paper, Internationalization is interpreted as "one of the ways in which higher education is responding to the opportunities and challenges of globalization" (King, 2003).

There are several ways to attain competitiveness and performance in the institutions of higher education. The transfer and acquisition of knowledge, mobilization of talent

for global academic and research pursuits, curriculum enrichment of international standards are some of the benefits of the Internationalization of higher education (Jibeen, 2015). The international collaborations among institutions of higher education have expanded considerably during the last few years (Cohen, 2014, Wildavsky, 2012, Aacsb, 2011).

The Internationalization in higher education majorly understood and manifested as

i. Knowledge transfer across the borders through books, journals or digital media
ii. Mobility of students, faculty and administrative staff
iii. International cooperation, academic collaboration and communication between the Universities and individual scholars.
iv. Research collaborations and imparting international education (working on research projects involving scholars from different countries, teaching/ learning of international languages, philosophies, intercultural learning etc.)
v. Internationalization at home (Creating opportunities for intentional learning through formal and informal experiences by introducing practices to promote Intercultural, International, and Global learning
vi. Developing Intercultural competence by organizing workshops, faculty development programs, International conferences, skill development programs etc.
vii. Create opportunities and provide financial support to the faculty and students to participate in International events abroad

The majority of the Universities in India have international dimensions in their academics and research, academics, which are more ad hoc, fragmented, and implicit than explicit and comprehensive (De Wit, 2020). In the fast few years, Joint academic programs, student and faculty mobility, branding, Global and national rankings have been some of the major indicators of the Internationalization in universities and the institutions of higher education (Teichler, 2017).

While the transfer of knowledge across borders, traditionally the core element of internationality of higher education, it is student mobility, which has become the most referred indicator for Internationalization in higher education.

International student mobility

International mobilization of the students is one of the most important trend that higher education institutions are witnessing in the twenty-first century. More than three million students are presently mobile, crossed geographic, cultural, digital, and educational borders in the pursuit of higher education abroad. It has compelled the educationists to look at their mission, strategies and operational practices.

"International mobility of students not only contributes to the internationalization of education institutions but also impacts on the outlooks and subsequent careers and lifestyles of the students themselves" a study group reported (Li, 2007).

There are various factors, which affect the decision of the students to select the University abroad for his/her higher education. Some of the factors which affect student mobility are; lack of institutions of higher education imparting quality education, limited seats and choices of courses, persisting economic, political problems, social and health-related issues in the home country, ineligibility to get enrolled in State/national level institutions, lesser job prospects in the home country.

The most pressing concern of the students enrolling for higher education is employment and job prospects when it comes to exploring the options for higher education. There is a strong need to design programs, which prepare students future job market and equip them with 21st-century skills.

The mobility of the students also promotes entrepreneurship. Through the exchange of ideas and knowledge transfer solutions to common problems in the society can be derived and there can be business relations established to provide solutions to various issues.

Some suggestions to improve Internationalization at home

Student Mobility

- Employability is a significant factor in the selection of higher education options abroad. The inclusion of Skill development courses, the curriculum which is more in industry demand, updating of the curriculum as per industry needs, inclusion of courses like International Business, Communication skills, foreign language, Computer languages, Critical thinking will undoubtedly add value to the existing programs.
- Organizing Industry-specific programs, industry-sponsored programs, internships, training, workshops for the students, teaching by industry experts, the participation of industry experts in designing curriculum and organizing technical events, competitions
- As the educational objectives of International students are different from Indian students, and exclusively designed curriculum which includes the core engineering courses as well as courses on Vedic Maths, Yoga, Indian classical music, Indian philosophy, Indian cuisines, Ayurvedic medicine, Indian languages will definitely attract the international students
- Students can be offered the opportunity to earn Micro degrees on specifically designed programs during short mobility.
- With growing digitization in education, subscription-based learning across countries seems to be an idea worth promoting and implementing.
- International collaborations not only promote Internationalization in education through research and academics but also solves various global problems. The pressing issues that the world is facing today, such as global warming, water pollution, energy crisis, etc. require higher education, industries, and government organizations to come forward and initiate working towards seeking solutions.
- Establishing offshore campuses of the university and offers courses specifically addressing to the local needs to produce employment-ready graduates will not only promote mobility but also improve the standard of education leading to healthy competition to impart quality education.
- Students need to be provided with the experience of international education through online co-teaching.
- Effective use of information technology and tools to make the teaching-learning process interesting the attention span of the students.
- Collaborative research, sharing of new methodologies, data leads to the validation of new methods across the globe in research and avoids bias for new methods.
- Organizing educational tours, industry visits for the international students and Indian students giving them opportunities to learn more about Indian work ethics and culture.
- Identifying niche technical areas and developing short-long duration programs for international students such as Data Science, Machine Learning, Vedic mathematics, Nanotechnology etc.
- Freedom to select courses across all the programs offered by the university for the international students with compulsory inclusion of skill development programs in the curriculum.
- Providing comfortable air-conditioned accommodation with attached kitchenette for international students to cook the food of their choice.
- Few sessions on teaching local language and Hindi during the induction program to International students to make it easy for them to interact with local vendors for their daily needs.
- Our International student alumni should be encouraged to hold sessions in their home countries, share their experiences with aspiring students, and encourage them to choose India for their higher education abroad.
- Encouraging international students to hold sessions on their culture, language, cuisines, music and dance for Indian students.
- Mandatory participation of Indian students of the institute in specifically designed international programs such as Industrial visits, Internships abroad, Summer schools, and winter schools.

- Mandatory enrolment and completion of one course offered by reputed university abroad based on the curriculum.
- Compulsory Capstone project under Co-supervision with International faculty/Industry expert.
- Organizing events encouraging cross-cultural communication as industries need skilled human resources to work efficiently with multicultural teams in a variety of situations and lotions.
- Offering scholarships, improved international student services, pathway programs, degree recognition schemes to increase student mobility.
- Participation in International fairs visits to Universities to popularise the programs offered by Symbiosis to International students.
- With increased mobile subscriptions and digitization in education, the geographical boundaries are collapsing. There is a dire need to create online content of a high standard and offering students across the boundaries. Such programs may be joint academic programs, including online teaching and actual contact hours.

Mobility of faculty/Staff

- Encouraging faculty to participate in international conferences, seminars, workshops.
- Research collaborations with international faculty.
- Writing joint research proposals for grants and publish research papers and books in collaboration with international faculty.
- Visiting universities abroad on research & teaching assignments.
- Inviting professors from abroad to teach, research, conducting FDPs /seminars/talks under various government schemes such as GIAN, SPARC, DUO fellowship etc.
- Inviting international faculty to co-supervise Ph.D. programs.
- Seek inputs/feedback from International faculty to design new programs, developing curriculum.
- Creating forums for frequent interaction with faculty from abroad.
- Incentivizing/acknowledging the efforts of faculty/staff for their contribution in bringing in Internationalization at home through research/academics.

Enhancing International Student mobility

Most of the countries around the world are trying to attract international students considering the major contribution by international student mobility in the Internationalization of their educational system. . More and more institutions of higher education are coming forward to initiate academic collaborations with universities abroad and signing academic agreements to promote student and faculty mobility.

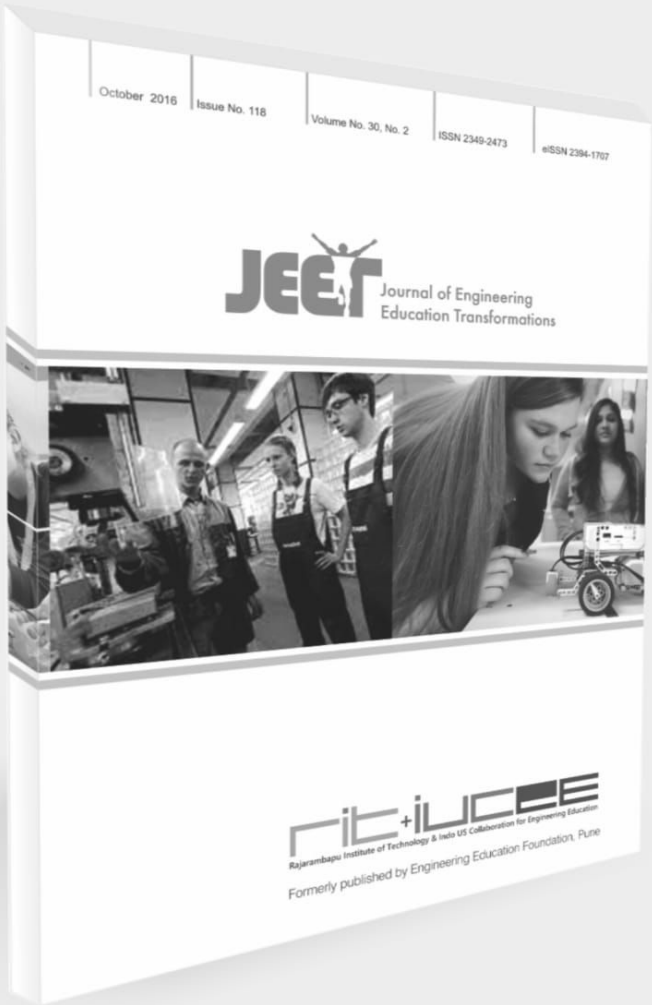
International students not only contribute towards increased revenue but also bring more diversity in the institutions of higher learning. The institutions need to ensure that their international students feel comfortable at home and look after well so that not only do they graduate successfully but also carry good memories with them and become the ambassadors of the institution. Minute attention is to be paid right from the induction of international students in the program until they graduate. Bridge courses, English-speaking programs, and other such programs help international students to adopt the new environment and culture quickly and align their skills and knowledge with local requirements.

It is also very essential that the curricula and teaching pedagogies should appeal to the global student market, enabling students to earn transferable or internationally recognized credentials. There is a strong need to understand instruction and assessment strategies for international students who might not be used to the local instructional and assessment methods. Though it is expected that international students will adapt to the local instructional and evaluation methods still there needs to be due consideration to be given to understand and anticipate the challenges and difficulties faced by international students.

Globalization is the fastest-growing phenomena the twenty-first century has witnessed. It brought along with it a dramatic transformation in the method of functioning of the institutions of Higher Education. Internationalization in higher education has become one of the prime agendas of the Universities and the institutions of higher education around the globe. The universities have realized their responsibility to equip their graduates not just with subject knowledge, but also with the required skills, ability to work in multinational, diverse environment and communicate effectively across cultures, techno perceptive and capable to handle ever-rising professional demands in this fast-changing globalized world. In this context, the institution of higher education is striving hard to develop its graduates with an international outlook and mindset and capable of functioning effectively. Internationalization in higher education can be brought in with a curriculum of international standards, the participation of students and faculty in international academic programs, International conferences, collaborative research, co-teaching of programs and offering exclusively designed programs, which will attract international students as having these students on campus have a direct impact on the Internationalization and cultural diversity of the institution.

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Determining the Characteristics of a Virtuous Teacher: Impact of Selected Virtues in Practice

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Abstract: Teachers are the incarnations of ethics, morals and values that they impart to the students with an aim to direct, educate and motivate students in accomplishing the mission of being a responsible citizen of the society. Studies claim that students tend to be more competent when they are able to apply virtues. As teachers play a significant role in forming and shaping the moral characters of their students, it is essential to understand that teachers set examples to their students by demonstrating through example. The role and the responsibility of the teachers is to disperse knowledge and information but little attention is been paid to the essential virtues that teachers need to adopt and introduce in the classroom. The main objective of the paper is to determine the characteristics of a virtuous teacher. Data for the study was collected from 423 teachers, teaching in schools, colleges and universities across India through a questionnaire that consisted of a number of components dealing with the characteristics of a teacher. Since it was difficult to accept all the components, factor analysis technique was implemented to condense the most essential qualities of a virtuous teacher. Further, co-relation and binary logistic regression analysis was implemented to find out how much impact these qualities create in order to define the characteristics of a virtuous teacher. Results indicated that the components that are essential to determine the qualities of a virtuous teachers are communication, fairness, responsibility, focus, care, humour, interest and commitment.

Key Terms: Teaching, Teachers, Students, Qualities, Virtuous

1. Introduction

Teachers are considered the epitomes of a leader who embody the intrinsic characteristics and skills to bring a radical change in the society for good. Teachers are interpreted as a role model, a leader who with their unique style motivate their students, engage in building their personality that plays an important role in shaping their career. Even an iota of morality induced within the temperament of the students can result in bringing tremendous changes in the society we live in. Hence, a teacher is considered as someone with a marked personality and embedded with a number of positive attributes. Green claims "the most effective teachers, researchers have guessed, must be more extroverted, agreeable, conscientious, open to new experiences, empathetic, socially adjusted, emotionally sensitive, persevering, humorous, or all of the above" (Green, 2014, 6). In fact, great teachers are a unique blend of both the ends of an attribute like being both extrovert and introvert, hilarious and sombre, flexible and severe and as and when situation demands for the betterment of the learners. There is no

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doubt that a good teacher is always and anyways good in concern with student relationships. The personal qualities of a teacher are very crucial for bringing out that effectiveness within themselves. But he still believes that "many of these personal or moral characteristics can be developed" (Cullingford, 1995). However, it all depends on the willingness of the teacher to be transformed into a better individual and achieve success. The failure he states is not because of lacking one or two personality traits but which are incompatible with the essential qualities of a professional teacher.

One of the most essential qualities that the teachers lack is reflecting on self or self awareness. Powell and Powell understand that "teachers who have self-awareness are more able to make learning pleasurable for their students and pleasure is essential to meaningful learning" (Powell and Powell, 2013). Self awareness has the tendency to introduce one to self and the deep seated emotions and values within. Emotions are quick drivers of actions and self awareness enables to make teachers composed and imperturbable however stressful the situations may be. These innate values are in fact the regulators and managers of self that manifest null response towards pessimism, despair and distress. These innate values define the practice of teaching through knowledge and the fundamental principles or virtues. Virtue ethics focuses primarily on virtues, or the goodness or the rightness of things, ideas, concepts, theories or principles. Devettere elucidates "virtue ethics arises from the natural inclinations embedded in human nature. It is rooted in our natural desires for what is pleasurable and good. Virtue ethics is about desire and not duty, about what we want to do and not what we ought to do about personal happiness and not the greatest happiness of all" (Devettere, 2002). Some of the core components of virtue ethics are thus the goodness or rightness of virtues "such as honesty, justice, compassion, dedication, diligence, integrity, courage and other components" (Campbell, 2003). Hence, a virtuous teacher is aware of using their insightful sense towards grooming the learners and also at the same time implementing their responsibilities to accomplish their goals.

Many authors believe that "teachers have an understanding about how to best customize content to fit the unique requirements of a situation and the capabilities of students. They are aware of the many obstacles to learning and know how to prevent potential problems before they occur. They know what learning is all about because they are committed, lifelong learners themselves" (Kottler, Zehm and Kottler, 2005). Teachers carry clarity and posses high beliefs regarding learning. An effective teacher best understands the requirements of the students based on each one's capabilities and shapes them as situation demands. It is because teachers were once learners and thus they are clearly conscious of the failures, challenges and opportunities during the process of learning. This makes them distinct from other members of the society.

However, an interesting fact on virtue ethics is that it is principles are self-contradicting. For example, an effective and a virtuous teacher who believes equality rely on treating everyone equally. That suggests a teacher as a moral person must ensure that caring should be equally bestowed on every student, but there might be few learners who need more attention, affection and care. In this case the teacher is violating the norm of equality and also justice that stipulates neutrality and equality. Further, a moral-bend teacher may have dilemma leading to conflict within self and further giving rise to self-doubt in their own profession and practice. Also, the practice of honesty, where a teacher feels to discuss regarding a student to another teacher, may violate the principle of confidentiality of keeping concealed the truth and reality of the student and the family and so on. While exploring these dilemmas, various broad approaches towards ethics emerge with still broader significance in the domain of philosophy.

2. Literature Review

The art of teaching is about mastering not only the subject and knowing how to deliver it through classes. The art of teaching is not again to simply help students to pursue knowledge but it is about a reflection of virtues to the students that the teacher is instilled in. Above all, a teacher is first a human and must possess the virtues of a human first that can be later narrowed down to being in a profession like teaching. The job of a teacher is full of challenges as a teacher has to face a little around 30-60 students at one time for a stipulated period every day. Teaching the bookish knowledge is not the ultimate aim of a teacher. In fact a teacher has a lot more to donate than just knowledge. In today's world where nothing is permanent only the memories of learning ethics and values from an ethical person remains undying. Many studies are of the view that students learn more from a teacher than their parents while other studies suggest just the opposite. Debates

on which teacher, the teacher at home or at the educational institution has a powerful impact on students still could not suffice the arguments. But the underlying fact is human of all ages have the attention towards someone whom they meet for a short period that is interaction with others in short doses for a lifetime memory. On the same argument, students meet their teachers daily but for a short span that is for limited hours and the interaction within that span is enough for the students to be influenced. However, the personality of a teacher also matters.

Aquino and Razon believe that "a teacher with a unique set of personal qualities such as geniality, sense of humour, enthusiasm, and sparkling facial expressions can contribute significantly to the mental, social, and emotional development of students" (Aquino and Razon, 1993). Although it is an obvious fact that not all teachers can have the above qualities however, every teacher should develop and adjust their personality according to the needs of the students. The sum total of both inner and outer qualities of a teacher reflects in the combination of thoughts and action. The personality of teacher is interdependent on the values and ethics that the teacher carries.

The effectiveness of a teacher does not simply depend upon the scores that the students get through learning neither the ineffectiveness of the teacher can be calculated on the same basis rather while an effective teacher makes learning for the students easy and comfortable through a proper and self-presentation, "an ineffective teacher makes it difficult for students to learn or decreases their desire to learn by a lack of enthusiasm for the subject, by a hostile or inappropriate behaviour towards the students, by a failure to maintain discipline in the class, or by unfairly preferring some students to others" (Kodero et.al, 2011). Stronge also has similar views on the same as he asserts "the primary difference between effective and ineffective teachers does not lie in the amount of knowledge they have about disciplinary content, the type of certificate they hold, the highest degree they earned, or the years they have been in the teaching profession, rather the difference lies more fundamentally in the manner in which they deliver their knowledge and skills while interacting with the students in their classroom" (Stronge, 2013). It is all about the self presentation of the inner values trough n appropriate behaviour in a proper manner. Ineffective teachers are thus distinguished from effective teachers in the sight of being ethical and virtues.

Studies indicate that "one of the keys to understanding is good communication. Communication is a means of promoting the curiosity, the inclination to question and the exercise of imagination which are vital for the motivation to learn" (Cairns, 2013). It is through communication that a teacher must be able to speak, listen, understand, feel and reciprocate. Teachers with great communication skills not only teach their concerned subject but also enable the students to share their feelings, opinions and beliefs with them. This makes the students stay motivated as they feel at ease to rely and trust on their teacher who they believe would provide them constructive and productive suggestions. Through communication ethical teachers are able to win the trust of the learners especially the adolescents and thus are able to protect them before they go astray. Thus, an effective student-teacher relationship is formed, long lasting and strong.

Patience is an ability that has more to do with the circumstances around us. Ryan understands that with patience situations get easily folded and controlled. He writes "patience helps us more love toward others, more at ease with the circumstances of our lives, and more bale to get what we want. It constantly rewards us with the fruits of maturity and wisdom: healthier relationships, higher- quality work and peace of mind" (Ryan, 2013). In teaching profession chiefly, the need to practice and implement practice is more as a teacher has to deal with different kinds of students with different learning abilities all at one go. Hence, a teacher has to stick with patience to receive the tranquillity in imparting knowledge to the students. In fact, patience to teachers comes very innately. Eaude understands "to teach young children, requires patience, given the immediacy of their responses and the frustrations inherent in the role. How teachers deal patiently with their own anger and frustrations provides an example to children of how to do so" (Eaude, 2018). Here comes the need to self control. Self control is an ability that comes with practice. Clendenin believes that self control governs our attitude. Clendenin writes "only through self-control can we have inner freedom, knowing that we can depend upon our actions and reactions, to some extent, when faced with decisions which must be made" (Clendenin, 1991).

Every student in the classroom is important and it is equally important to make every student happy, playful, and joyful so that learning becomes easy. And the teacher teaches with added humour so that

students enjoy every part of the teaching. Boring classes are not only less interesting but also make learning difficult. Hence, it is the responsibility of the teacher to teach the students in such a way that students fee attracted for the class. Fun, humour, entertainment makes classes, teaching and learning all the way more effective. However, overdoing the same would result in disrespect to the teacher and also the classes go empty. Some students who are really interested in knowledge acquisition find it frustrating. Many arguments on implementing humour by the teachers suggest that there has to be balance maintained in class room. "Teachers should not be frivolous or try to be entertaining all the time, but neither should they be humourless or over serious. Some teachers may not wish to use humour much, but there is a place for material to be presented in eccentric or funny ways, not least because this may help to engage young children's interests" (Clendenin, 1991). Tauder too has equal views on the same as he claims "when humour is used as a supplement to, and not a substitute for, teaching, it's most positive benefits to classroom management come forth. Effective use of humour reinforces the teacher's superior position in the classroom" (Tauber, 2007).

Teachers who are passionately committed constantly offer brilliant results for their institution. Such teachers not only love their work but also love to learn more and adopt new techniques in teachings so that they can deliver the best of knowledge to their students. "Passionate teachers are aware of the challenge of the broader social contexts in which they teach, have a clear sense of identity and believe that they can make a difference to the learning and achievement of all their pupils" (Day, 2004). Commitment for them is not simply the commitment of their duties i.e. maintaining a six-seven hours job but also a commitment to self-upgrade for the betterment of students, institution and society as a whole. Such passionate teachers love their job and their students not for the income but for the recognition they earn in preserving their and the institutional integrity.

Interestingly, according to the findings of a project conducted by the Jubilee Centre's research, the primary qualities essential for a good teacher are "fairness, creativity, love of learning, humour, perseverance and leadership" (Arthur , Kristjánsson , & Cooke , 2015) and these qualities in fact enable a teacher to stay focused and do something right not just to impress the students people around or to sabotage things but to satisfy the motivation of the strong beliefs a teacher need to carry.

Still more studies conducted on assessing what makes a good teacher claim that teachers need to put a lot of efforts into helping students with learning acquisition. Besides, the studies claimed that "personal attention, dealing with the students' problems, fair treatment and showing respect" (Ida, 2017) among other qualities must be taken into consideration to prove a teacher to be enough.

Another survey was conducted with regard to the most common virtues and over one hundred teachers participated where these teachers "focused explicitly on demonstrating respect and the basis of this respect almost always derived from the particular theological belief that all students are made in God's image" (Glanzer, Alleman, & Marsden, 2019, p. 91). The survey included many Christian professors and interestingly, the professors included this theologically- derived virtue as an essential part that serves as a foundation in their classroom pedagogy as well.

In a more recent study, the underlying features that add up to the characteristics and dispositions of a good teacher essential in both twentieth and twenty-first century is a "teacher's knowledge of the subject matter or the content they teach is a key to effective teaching and student learning" (Merriman, 2020). Teachers must have immense competence to shape student's way of learning and help in achieving gains. Besides knowledge and content the pedagogical skills are also important. A teacher should have the ability to deliver their knowledge properly through proper planning and strategies including incorporation of appropriate virtues.

Among all other professions teaching has become progressively more intricate profession that demands the top levels of professional practice in order to execute it finely. However, just like other professions, core professions like teaching has today been succumbed to exigency. Amidst all crisis and hopelessness, there still remains a great optimism and hope regarding the scope of teaching and learning that is staunchly bound with its vision to raise the educational standards. One of the most important aspects of education and teaching as a profession is the inclusion of ethical knowledge it is pedagogy. However, time and again this aspect has been neglected so much so that teachers today are recruited

on the basis of the knowledge on the subject area they prefer to teach and the highest degree of qualification they carry on that subject. "Curiously, though, almost no attention is paid to the ethical or moral knowledge that teachers need to inform their professional judgements and guide their relations with children, colleagues and others" (Campbell, 2003). What is fascinating yet frustrating is that no educational institution is concerned with the ethical approach towards pedagogy and its impact on students as learners and considering it more compelling and practical. Hence, its time teaching professionals should be more serious and committed about accomplishing and implementing virtues in their profession.

3. Research Gap

The literature review reveals that a teacher carries a number of ethics and principles and most of the studies deal with the theoretical perspectives of virtue ethics. The literature makes us draw the conclusion that although there are many essential qualities that may categorize a teacher as virtuous, however, the current study focuses on condensing these qualities by implementing quantitative techniques through random sampling method. Further, the paper also emphasizes on how much impact these components create in determining the essential characteristics of a virtuous teacher so that the same can be incorporated by the teachers for the benefit of the students and society.

4. Methodology

A. Materials

The study was conducted through quantitative technique by data collection from 423 teachers with experience ranging from 0 to 10 years and above. The teacher participants were introduced about the research topic and were requested to fill the questionnaire. The first segment consisted of personal information extracting the background information of the participants. Questions on gender, age groups, and years of experience were asked first. The second segment consisted of 23 questions that described a teacher's attribute of being honest and decently upright with students. These questions mostly dealt with moral reflection of a teacher towards students. All the questions had options like never, not often, sometimes, often, and always.

B. Participants

Participants in the study were teachers selected from various schools, colleges and universities in India through simple random sampling method. The sample of the present study consisted of 423 teacher participants. Of them, 129 (30.50%) were male and 294 (69.50%) were female. Of those sampled, 155 (36.65%) had less than 5 years of experience in teaching, 94 (22.22%) had experience between 5 to10 years of teaching and 174 (41.13%) had more than 10 years of teaching.

In the next segment teacher participants were asked on their ability to deal with students implementing various techniques. Summarizing this segment, when asked about if communication is an important virtue in the teaching profession, 191 (45.15%) agreed that communication is in fact an important virtue. Further, 157 (37.11%) mentioned that they can never be unbiased with means and approaches to get the solution to the problem of their students. Next, 321 (75.88%) mentioned that when they initiate a discussion of something important, they always make a way for their students to explain their viewpoints. Furthermore, 248 (58.62%) mentioned that they don't hesitate to ask for more information and clarification from their students when required. Next, 340 (80.37%) are good listeners as they listen fully and affirm that they understand what their student say.

Coming to the next question 333 (78.72%) revealed that they understand each student is different. 298 (70.44%) asserted that they pay attention to every student's needs. Further, 301 (71.15%) mentioned that they are concerned more about students' present than students' future. On asking if they believe patience is an important virtue in the teaching profession 145 (34.27%) mentioned they always believe so. On asking if they help students to identify their learning needs and objectives 299 (70.68%) mentioned they always do so.

Further, questions on engaging the students were asked to the teacher participants where at least 166 (39.24%) always make their students laugh by telling humorous stories about themselves. Moreover, 189 (44.68%) usually can think of witty things to say when they with their students. Next, 118 (27.89%) asserted that their students often admire their humorous quality. Next, 178 (42.08%) agreed that humour is an important virtue in the teaching profession.

Further questions clarified that 322 (76.12%) believe that it is their responsibility to ensure good social relations among their students. While 324 (76.59%) mentioned that they believe their willingness is very important to be engaged in the teaching work, 173 (40.89%) revealed that they are so involved with their profession that they are willing to work beyond office hours. On asking if they can go to any extent to enhance and develop their attitude required in the teaching profession, 244 (57.68%) asserted they would. Further, 228 (53.90%) revealed that if they could get a job different from being a teacher and paying the same amount, they would never take it. 372 (87.94%) participants mentioned when students make them angry, they never deal with them while still angry. Next, 344 (81.32%) asserted they focus on one student at one time. Lastly, 273 (64.53%) revealed that they often go overboard in putting themselves down when making jokes or trying to be funny with their students.

C. Procedure

In order to find out whether the data collected through the questionnaire is reliable and valid, Cronbach's Alpha was performed. Further, as there were 23 components that signify the characteristic of a virtuous teacher and as it is not possible to accept all the components hence factor analysis was conducted that condensed all the 23 components into 8 most essential virtues of a teacher. Next, correlation matrix was performed to assess the correlation between all the independent variables and dependent variable that is characteristics of a virtuous teacher. Lastly, binary logistic regression analysis was performed to check how much impact each of these 8 characteristics have on determining the qualities of a virtuous teacher. Further, the paper also studied the applicability of this model as a predictor for future studies of such kind.

D. Data Reliability and Validity

Table 1 below shows the reliability test done through SPSS in the study. Cronbach's Alpha was performed and the values demonstrated that the reliability level was found to be 0.735. This further shows that the data itself has 73% of accuracy and reliable as the data reliability is >.70.

Table 1: Reliability Test

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.700	.735	26

E. Factor Analysis

Table 2 below shows that out of 23 components, total 8 components are the most essential qualities of a virtuous teacher which has 62.912% of variance for this model. The table below randomly selects the 8 components. However, the names and variance of each component that are analysed is shown in component matrix in Table 3.

Table 2: Component Analysis

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.740	16.259	16.259	3.740	16.259	16.259	2.249	9.779	9.779
2	2.719	11.822	28.081	2.719	11.822	28.081	2.160	9.392	19.171
3	1.677	7.292	35.373	1.677	7.292	35.373	1.877	8.160	27.331
4	1.471	6.395	41.768	1.471	6.395	41.768	1.764	7.671	35.002
5	1.440	6.262	48.030	1.440	6.262	48.030	1.744	7.582	42.584
6	1.257	5.467	53.497	1.257	5.467	53.497	1.742	7.573	50.157
7	1.122	4.877	58.374	1.122	4.877	58.374	1.598	6.947	57.103
8	1.044	4.537	62.912	1.044	4.537	62.912	1.336	5.808	62.912
9	.964	4.190	67.102						
10	.872	3.790	70.893						
11	.762	3.314	74.206						
12	.723	3.142	77.348						
13	.665	2.892	80.241						
14	.642	2.790	83.031						
15	.598	2.601	85.632						
16	.546	2.372	88.004						
17	.517	2.250	90.254						
18	.463	2.014	92.268						
19	.452	1.965	94.233						
20	.430	1.868	96.101						
21	.358	1.556	97.656						
22	.299	1.299	98.955						
23	.240	1.045	100.000						

Extraction Method: Principal Component Analysis.

Only cases for which VirtuousTeacher = Virtuous are used in the analysis phase.

F. Component Matrix

Table 3 below shows the component matrix that depicts the sequence of the essential qualities of a virtuous teacher highlighted in blue and accordingly the component matrix values are highlighted in red.

G. Correlation Matrix

Table 4 below shows a significant co-relation between the dependent variable and the independent variables through correlation matrix. The table shows the correlation values of the variables.

Table 3: Component Matrix

Component Matrix[a,b]

	Component							
	1	2	3	4	5	6	7	8
Communication	-.058	.172	.442	.167	.253	.447	.276	-.231
Fairness	.142	-.025	.003	.555	-.405	-.143	.425	-.121
Facilitation	.136	-.414	-.368	.427	.210	.173	-.026	.244
Understanding	.439	.115	-.110	.350	.149	.198	.131	-.494
Listening	.459	-.270	-.225	-.114	-.157	.401	.177	.231
Perception	.472	-.184	-.197	-.165	.352	-.068	.010	-.417
Attachment	.413	-.145	-.082	.141	.274	-.315	-.208	.098
Responsibility	.384	.301	.143	.148	.125	.297	-.355	.359
Patience	.097	.337	-.047	-.021	.674	-.111	.087	.240
Nurture	.502	-.164	.079	-.462	.137	-.263	.132	-.123
Care	.164	.592	-.220	-.001	-.031	-.426	-.075	-.060
Wit	.291	.452	.059	.307	-.018	.116	-.409	-.086
Cheerful	.434	.430	-.279	-.029	-.509	.073	-.058	.044
Amusing	.368	.437	-.581	.006	.059	.052	.143	.080
Humor	-.016	.490	.497	-.284	-.172	.113	-.133	-.032
Contribution	.589	-.174	.042	-.411	-.071	.269	.273	.205
Interest	.598	-.210	.217	.009	-.035	-.286	.224	.158
Involvement	.506	.180	.478	.072	.046	-.126	.048	.016
Growth	.470	.061	.399	.369	-.058	-.275	.159	.251
Commitment	-.077	.524	.036	-.017	.276	.202	.316	.118
Attitude	.580	-.336	.112	.037	.073	.164	-.304	-.220
Focus	.510	-.495	.129	.003	-.147	.064	-.248	-.011
Enthusiastic	.522	.481	-.166	-.216	-.160	.042	-.003	-.143

Extraction Method: Principal Component Analysis.
a. 8 components extracted.
b. Only cases for which VirtuousTeacher = Virtuous are used in the analysis phase.

Table 4: Correlation Matrix

Correlations

Control Variables			Communication	Fairness	Responsibility	Patience	Care	Humor	Interest	Commitment
VirtuousTeacher	Communication	Correlation	1.000	.091	.072	.055	.028	.131	.023	.142
		Significance (2-tailed)		.062	.141	.261	.564	.007	.641	.003
		df	0	420	420	420	420	420	420	420
	Fairness	Correlation	.091	1.000	.046	.056	.004	.053	.225	.072
		Significance (2-tailed)	.062		.351	.253	.942	.277	.000	.140
		df	420	0	420	420	420	420	420	420
	Responsibility	Correlation	.072	.046	1.000	.187	.064	.101	.112	.090
		Significance (2-tailed)	.141	.351		.000	.186	.039	.022	.064
		df	420	420	0	420	420	420	420	420
	Patience	Correlation	.055	.056	.187	1.000	.148	.060	.019	.217
		Significance (2-tailed)	.261	.253	.000		.002	.222	.697	.000
		df	420	420	420	0	420	420	420	420
	Care	Correlation	.028	.004	.064	.148	1.000	.154	.010	.120
		Significance (2-tailed)	.564	.942	.186	.002		.002	.841	.013
		df	420	420	420	420	0	420	420	420
	Humor	Correlation	.131	.053	.101	.060	.154	1.000	-.029	.231
		Significance (2-tailed)	.007	.277	.039	.222	.002		.552	.000
		df	420	420	420	420	420	0	420	420
	Interest	Correlation	.023	.225	.112	.019	.010	-.029	1.000	.077
		Significance (2-tailed)	.641	.000	.022	.697	.841	.552		.116
		df	420	420	420	420	420	420	0	420
	Commitment	Correlation	.142	.072	.090	.217	.120	.231	-.077	1.000
		Significance (2-tailed)	.003	.140	.064	.000	.013	.000	.116	
		df	420	420	420	420	420	420	420	0

H. Binary Logistic Regression Analysis

Table 5 below shows the Binary Logistic Regression processing summary that demonstrate selected cases for the study. The table also shows there is no missing data for the study.

Table 5: Case Processing Summary

Case Processing Summary

a		N	Percent
Selected Cases	Included in Analysis	423	100.0
	Missing Cases	0	.0
	Total	423	100.0
Unselected Cases		0	.0
Total		423	100.0

If weight is in effect, see classification table for the total number of cases.

Table 6 below is the Beginning Block that shows the classification matrix of the original sample set of 423 respondents, 320 respondents are considered virtuous and 103 as non virtuous

Table 6: Classification Matrix

a,b

Observed			Predicted		
			Virtuous Teacher		Percentage Correct
			Virtuous	Not Virtuous	
Step 0	Virtuous Teacher	Virtuous	320	0	100.0
		Not Virtuous	103	0	.0
	Overall Percentage				75.7

Constant is included in the model.

The cut value is .500

Table 7 shows that 303 respondents believed that there are 8 most important qualities which determine a virtuous teacher. Further, the table predicts that this study will be 83.2% effective in future work of similar kind.

Table 6: Prediction

Observed			Predicted		
			Virtuous Teacher		Percentage Correct
			Virtuous	Not Virtuous	
Step 1	Virtuous Teacher	Virtuous	303	17	94.7
		Not Virtuous	54	49	47.6
	Overall Percentage				83.2

The cut value is .500

5. Findings

Findings indicate that after implementing factor analysis technique in Table 2 a total of 8 components were received. However, it was not specified as to which 8 components are in fact essential to determine the characteristics of a virtuous teacher. Further, component matrix in Table 3 reveals the essential qualities that are communication, fairness, responsibility, patience, care, humour, interest and commitment as important characteristics of a virtuous teacher. Results were drawn based on the highest value achieved from the respective component matrix. The correlation matrix in Table 4 portrays that considering virtuous teacher as the control variable, the 8 components are positively correlated with each other. However, 2 components that are humour and interest have a slight negative correlation with each other having regression value of -.029 without impacting the main objective of the study. Findings, of the binary logistic regression analysis in Table 5 indicate that out of 423 cases not a single case was missed out. Further, 320 respondents are considered virtuous and 103 as non virtuous. However, the findings in Table 7 predicted that 83.2 % of the data is correct and can be implemented in further work of similar kind.

6. Critical Discussions

In the framework of studying, and the research that has been carried out, results indicated that to determine the characteristics of a virtuous teacher, although there might be various components that signify the same but there are 8 most essential qualities that fulfil the objective of the study. Critical discussion underlying the results may indicate that virtuous teachers need to be great communicators as a virtuous teacher's communication skills is viewed as naturally relational that fosters the development and growth of the students. Further, fairness is another important attribute of a virtuous teacher as fair teachers are intrinsically motivated to do justice with every student irrespective of gender, cast, religion or status. For a virtuous teacher every student is unique and hence a virtuous teacher ought to implement pedagogical methodologies fairly for every student. The next important role that a virtuous teacher has to impart is responsibility towards the students in order to enable and empower each student to emerge as a competent personality. A virtuous teacher's responsibility should not be restricted to classroom teaching only rather beyond the four walls of the classroom where the teacher provides enough space and opportunity to the students so that they can learn further than the syllabus. Patience is another essential quality that a virtuous teacher needs to possess as patience brings a teacher closer to the students' inner abilities and potentials, understand that no students are alike and that they behave, learn and act according to their potentialities. Besides the other aspects, a

virtuous teacher ought to be caring towards the learners. Students often feel demotivated in the process of learning specifically if they are learning something new. At such a point, a virtuous teacher is someone who understands the setbacks of the learners and helps them learn and grow. Next essential quality of a virtuous teacher is interest because much of the students' growth and development is dependent on the interest that they take to personally understand their needs and provide efforts to work on them. Next virtue is humour that a virtuous teacher ought to possess as a perfectly weighed humour when incorporated in class makes it more lively and enthusiastic. Commitment as another factor makes teachers believe through their attempt to recognise the challenges; they can bring a drastic change and difference in the approaches towards making their students better individual.

7. Conclusion

An ethical teacher is self-disciplined and follows a number of sub genres. The study demonstrated that a virtuous teacher carries some of the most essential qualities like communication, fairness, responsibility, patience, care, humour, interest and commitment. In fact, these qualities enable a teacher to be virtuous so as to set out a good example to students. Virtuous teachers ought to be honest in their work in dealing with the students, loyal to the success and failures and remain trustworthy so as not to reveal their weaknesses to others. There is a growing need to incorporate and implement virtue ethics in teaching profession as it not only makes a teacher a good human being who is responsible for innumerable students and their future by shaping and moulding them through ethics but also providing the students an opportunity to learn the same from the teachers. It is of utmost importance that students get an in depth knowledge, awareness and a motivation that pushes them to be better individuals every day. However, teachers being the role models for the students must be first virtuous and understand their duties towards students. The act of virtues incorporated in the art of teaching improvises the position and dignity in teaching profession persistently and throughout the life. This paper studied the 8 most important qualities that determine a virtuous teacher particularly not as a requirement but as a demand to meet the challenges of the various social contexts.

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Questionnaire

All the questions have the options like *1- Never, 2- Not Often, 3- Sometimes, 4- Often, 5- Always*		
Sl. No.	**Components**	**Questionnaire**
1	Communication	Communication is an important virtue in the teaching profession.
2	Fairness	I can be unbiased with means and approaches to get the solution to the problem of my students.
3	Facilitation	When I initiate a discussion of something important, I always make a way for my students to explain
4	Understanding	I ask for more information and clarification from my students when required.
5	Listening	I listen fully and affirm that I understand what my student says.
6	Perception	I understand each student is different.
7	Attachment	I pay attention to every student's needs.
8	Responsibility	I am concerned more about students' present than students' future'.
9	Patience	Patience is an important virtue in the teaching profession.
10	Nurture	I help students to identify their learning needs and objectives.
11	Care	I always make my students laugh by telling humorous stories about myself.
12	Wit	I usually can think of witty things to say when I'm with my students.
13	Cheerful	Making my students laugh is my natural way of communicating with my students.
14	Amusing	My students often admire my humorous quality.
15	Humor	Humor is an important virtue in the teaching profession.
16	Contribution	It is my responsibility to ensure good social relations among my students.
17	Interest	I believe my willingness is very important to be engaged in teaching work.
18	Involvement	I am so involved with my profession that I am willing to work beyond official hours.
19	Growth	I can go to any extent to enhance and develop my attitude required in the teaching profession.
20	Commitment	If I could get a job different from being a teacher and paying the same amount, I would take it.
21	Attitude	When students make me angry I deal with them while still angry.
22	Focus	I focus on one student at one time.
23	Enthusiastic	I often go overboard in putting myself down when I am making jokes or trying to be funny with my

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Assessment of Course Outcomes Attainment using Confidence Limits

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Abstract: Course Outcomes (CO) assessment is one of the most important components of Outcome Based Education (OBE) to describe the specific type and level of learning students. The programs must have an effective end results in every course and their systematic assessment with proper documentation and should evaluate continuously to establish certain standards leading to program accreditation. In the calculation of CO attainment, the mean values are usually considered as a target values but it may create ambiguity in decision making. The target value in conventional method is unbounded on the upper and lower ends, which undermines interpretations of student's category associated with their performance. In this paper an attempt has been made with a new approach for calculation of CO attainments based on Lower Confidence Limit (LCL) and Upper Confidence Limit (UCL) and compared against conventional method. This comparison has shown that the proposed method showed a nontrivial improvement over existing conventional method and found more flexible, relatively well behaved, and applicable to a wide range of students' categories. Further, proposed method has the advantage of being useful in framing appropriate syllabi of courses and in making effective strategy to improve students' performance.

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Keywords: Outcome Based Education, Lower Confidence Limit, Upper Confidence Limit, Attainment of Course Outcome

1. Introduction

Static material or master classes based traditional teaching methodologies are not always the best approach to promote learning. These methods mainly focus on what is taught. The Outcome Based Education (OBE) is a pedagogical student-centric model entails the restructuring of curriculum, pedagogy and assessment practices to ensure high-order learning. Therefore, to recognize and facilitate the standardization of professional courses, OBE has been recommended by (Washington Accord on 13 June 2014). India is officially a member of the Washington accord from 13thJune 2014 with the permanent signatory status of the National Board of Accreditation (NBA). All India Council for Technical Education (AICTE), a statutory body of India has adopted the OBE to train the engineering graduates for better knowledge, skill sets, attitudes, global mobility and acceptance (Ramchandra et al., 2014). All the higher education level technical institutions of India are following OBE as per the guidelines issued by AICTE. Course Outcomes (CO), Program Outcomes (PO) and Program Educational Objectives (PEO) are the main key components of OBE. Based on how well these components are defined and evaluated, OBE attainment is measured. Literature shows plenty of reports on direct assessment method (Bassi et al., 2015; Biney and Bryant, 2010; Gurocak, 2008; Memon and A Harb, 2009; Rajak et al., 2018;

Roy et al., 2015; Shaeiwitz and Briedis, 2007; Terang et al., 2015; Turkmen et al., 2010). PEO and PO are eventually depended on CO attainment. Recent studies focuses on the methodology for assessment of CO attainment. Chandna, 2015 discussed the methodology for CO assessment and improvement on weak student through Massive Open Online Courses (MOOC) Innovation and Technology. Balasubramani and Chiplunkar, 2017 demonstrated the process of CO attainment and its contribution to PO. Rajak et al., 2019 discussed how gap analysis is performed when CO does not meet to its target. Premalatha 2019 discussed on guidelines of CO-PO mapping and its attainment models. Kulkarni and Barot, 2019 proposed a method based on assigning two step weights best suited to the evaluation scheme of a course and their mapping with CO for engineering course. Therefore, institutes have shifted their focus on CO attainment.

The OBE model involves documentation of students learning outcomes' achievement, setting of appropriate target values, and gap analysis. In OBE, teaching learning activities are planned and organized such that the CO attainment can achieve the set target value. The department critically analysed the deviation of CO attainment from set target value. Department carries out gap analysis for the course which is not achieved expected CO attainment. The subject teacher has to submit justification with the reasons for the non-attainment of course outcome to the department. CO assessment is useful to map the quality of teaching and delivery, across divisions and departments, to evaluate faculty and students performance, to gauge students' understanding and knowledge in different segments of the course. It provides a feedback to the faculty and helps in improving the teaching-learning process.

CO is set of statements that describe what students should be able to do at the end of a course or subject. The CO attainment largely depends on set target value. Target value usually taken as mean value. The target values are revised from time to time based on the degree of attainment of the vision and mission of the department or institute. Thus setting of target value has been a key issue in the process of CO attainment. In this paper, lower confidence limit (LCL) and Upper confidence limit (UCL) are deployed in place of mean to set target values for determination of expected CO. The main objective of this study is to assess CO attainment more effectively using confidence limits. Finally, the overall applicability of the traditional method and proposed method are examined by evaluation of CO attainment for six coursesof semester 5 of B. Tech Civil Engineering Program.

2. Methodology

OBE formulates content around activities that leads to increase the proficiency of a particular skill, knowledge, or behaviour of the student. In this approach the learner's mastery over a particular skill is demonstrated and measured and the curriculum are driven by the exit learning outcomes of the students at the end of the program. CO attainment mapping is critical part of OBE and hence, CO should be stated in clear, specific, and measurable terms. The main focus is on what the student will be able to do as a result of taking the course and describe what the learner can draw from the knowledge, skills, and experiences acquired in a course.This assessment can be done directly or indirectly. In the present study only direct assessment is taken into consideration.

In traditional method CO attainment measured by comparing output with target value (average (AVG) value of the marks. Instead of a single estimate for the mean, a confidence interval generates a lower and upper limit for the mean. Confidence limits for the mean (Snedecor and Cochran, 1989) are an interval estimate for the mean. Interval estimates are often desirable because the estimate of the mean varies from sample to sample. The interval estimate gives an indication of how much deviation occur in true mean estimation. Narrower interval indicates more precise estimation. The motivation of this study is to articulate the outcome based process to achieve CO attainment based on LCL with 95% confidence for any under graduate (UG) program. They can be used to categorise students in to three different levels according to their level of understanding. The LCL indicates the minimum attainment level whilst the UCL indicates the maximum attainment level of CO and both can be reported with 95% confidence. In the present study target value set based on LCL.AVG method is based on sample mean which is the most common point estimate. It is easy to calculate and understand but it gives no indication of how accurate the estimation really is. To deal with uncertainty, an interval estimate LCL method is proposed. It provides a range of values that best describe the population.The interval estimate is a range of values used to estimate a population parameter and is associated with a specific confidence level.

In this study, CO of six courses of semester 5 of B. Tech Civil Engineering Program was assessed based on LCL. Traditionally CO attainment determine by taking means of marks obtained by the students in the courses.In statistics, the confidence interval is the range that a population parameter is likely to fall into, for a given probability. For given population and a probability of 95%, the confidence interval is the range in which a population parameter is 95% likely to fall.Note that the accuracy of the confidence interval relies on the population having a normal distribution.

To calculate the confidence limits for a measurement variable, multiply the standard error of the mean times the appropriate critical Z-value. The critical Z-value is determined by the probability (0.05 for a 95% confidence interval) and the sample size. The confidence interval tells you how confident you are in your results.

Confidence limits for the mean (M) are an interval estimate for the mean (Snedecor and Cochran, 1989). The mean value has characteristic to vary sample to sample therefore, Interval estimates are often desirable. A confidence interval generates a lower and upper limit for the mean. The LCL and UCL are calculated by using Equation (01) and (02) respectively.

$$LCL=M-Z_{(\alpha/2)}*\frac{\sigma}{\sqrt{n}} \qquad 01$$

$$UCL=M+Z_{(\alpha/2)}*\frac{\sigma}{\sqrt{n}} \qquad 02$$

Where Z is a numerical critical value calculated based on the alpha (α=1-confidence level). Mathematically we use the Z table to calculate the critical Z value. To calculate the confidence interval we need to calculate the margin of error ($Z(\alpha/2)*\sigma/\sqrt{n}$). Subtracting this error value from mean value will give the lower limit of interval and adding the error value to mean value will provide the upper limit of the interval. Confidence limits are expressed in terms of a confidence coefficient. The confidence coefficient may be expected to contain the true mean.After determination of LCL and UCL, students are categorized in three different levels (L1<LCL, L3>UCL and LCL=<L2=>UCL). Estimate the individual CO attainment in % based on LCL. After completion of direct assessment estimate individual CO. Units of the course not equally contribute to the final average, some unit contributes more weight than others. The weighted mean (Everitt and Skrondal, 2010) makes it possible to account effect of units in computation of CO. Weighted COwi for each course are determine by considering LCL based individual CO for each course and equivalent weight of unit using the following equation (03):

$$CO_{wi} = \frac{\sum_{j=1}^{N} CO_j \, UN_j}{\sum_{j=1}^{N} UN_j} \qquad 03$$

Where

COwi=Weighted CO for each course i in a semester

N=Number of Units

COj=Individual CO measured based on LCL for course j

UNj=Unit weightage in % for each CO j

The composite COci is calculated as the weighted average of the COwi by accounting the credits of each course. Estimate the composite COc for each semester. The COci is computed by using equation (04):

$$CO_{ci} = \frac{\sum_{j=1}^{N} CO_{wj} \, CR_j}{\sum_{j=1}^{N} CR_j} \qquad 04$$

Where

COci=Composite CO for each semester i

N=Number of courses

COwj=weighted CO of each course j

CRj=Credit for each course j

The procedure of CO attainment and scaling it in 1 to 3 is presented in flowchart (Fig. 1).

3. Result and Discussion

In order to attain the PO, the course curriculum of the program is designed in a manner that the students get trained in the entire 12 PO of the Program. The courses are taught to the students by various teaching methodologies like class room teaching, laboratory experiments, seminar, projects, invited talks, internships, supplemental instructions (Peer group study), etc. Each course is designed with specific CO

and each CO is mapped to the PO. The CO was formulated by subject expert taking inputs from various stake holders from Academician, Alumni, and Industry etc. A CO and Course units are formulated and presented in Table 2. In this procedure care must be taken that each CO must be mapped at least one unit (Chapter) of the course. The department has to formulate 12 PO based on twelve NBA graduate attributes. A CO-PO correlation is mapped in scale 1 to 3 as shown in Table 2.

In this study, an innovative methodology to measure CO attainment for course and semester is proposed and presented. Question paper should adequately be addressed the weightage assigned to each unit and the entire CO of the course. The weighted CO for each course and composite CO for each semester are calculated by using equation (03) and (04) respectively. Calculations of CO for all six subjects of 5thsemester of B. Tech Civil Engineering program are presented in Table 3-8.

CO attainment for each course by both the method (LCL and AVG) are presented in Table 3-8. In this study, internal assessment of 115 students of 5thsemester was carried out. Similar methodology can be applied for external and practicals assessment. In this method students can be categorized into three different levels L1-Slow learner, L2-Medium learner and L3-Advance learner according to their performance. Faculty members can prepare action plan according to students' level for better performance. The highest difference (20.64) is observed in CO6 of (30040506) course while lowest difference (-2.54) is shown in CO1 of (30040502) course between LCL and AVG method. According to LCL method, highest CO1 attainment is recorded 89% for (30040505) course and lowest CO6 attainment noted 15% for (30040506) course. AVG method measured highest CO1 attainment 91% for (30040505) course and the lowest CO6 attainment 19% for (30040506) course. Table 9 shows the individual CO attainment for each course by both the method. It is reveal from Table 9 that LCL method explicitly indicates overall class level of students. L1 implies poor and medium performance while L3 indicates medium and strong performance of students in particular course. It is seen that CO1 and CO2 strongly attained, CO4 and CO5 are moderately attained and CO3 and CO6 are not adequately attained. This is due to CO3 and CO6 have more marks as compared to others. Depending on the weightage of marks, in this section analysing, evaluating and designing problems were usually asked.

Weighted CO for each course by taking into account weightage of course units and Composite CO for entire semester was computed based on credit of course. Weighted CO and Composite CO are computed and displayed in Table 10. LCL method computed highest weighted CO 71.63% for (30040502) course and lowest weighted CO 45.21% for (30040506) course while AVG method estimated highest weighted CO 66.33% and lowest weighted CO 45.39% for the same courses. LCL method underestimated the weighted CO for 30040504 and 30040506 courses. The results obtained by LCL method differ the results of AVG method in range from -0.21% to 7.99%. LCL method overestimated composite CO. The difference in composite CO estimation is 3.14%. Attainment of weighted CO and Composite CO can be useful in upgradation of course contents and teaching schemes.

4. Conclusions

In the present study the CO attainment method based on confidence level limit is proposed for Under Graduate Engineering Program. The results obtained by traditional (AVG) method and proposed (LCL) method are compared. The results obtained by proposed (LCL) method are indicated that LCL method contributes towards making the more effective CO attainment with specific confidence level. In this study, internal assessment of 115 the pre-final year students was carried out and the methodology can be applied for external and practicals assessment. Attainment of weighted CO and Composite CO can be useful in up gradation of course contents and teaching schemes. Proposed methodology divides students in three different levels based on LCL and UCL target values which would help in making action plan for further improvement of students of equal level. Weighted CO by considering weights of units and Composite CO by taking into account of course credit is proposed for upgradation of course contents and teaching schemes. Attainment of weighted CO and Composite CO are helping in upgradation of course contents and teaching schemes. This work will help in assessing the teaching learning process of the department and thus would help in calculating the CO attainments of each semester of the Under Graduate Engineering Program.

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Table 1 : CO Attainment calculation for each Course

<table>
<tr><th colspan="2">DIRECT TOOLS</th></tr>
<tr><td>SUBJECTS (Theory) Internal and External</td><td>Calculate CO based on LCL for Internal and External Evaluation and scale it 1 to 3.
<table>
<tr><td>CO %</td><td>>60</td><td>>=50 and <=60</td><td><50</td></tr>
<tr><td>Score</td><td>Strong</td><td>Medium</td><td>Poor</td></tr>
<tr><td>Attainment</td><td>3</td><td>2</td><td>1</td></tr>
</table>
Net CO=40% Internal + 60% External</td></tr>
<tr><td>SUBJECTS (Practical/ Laboratory, Internship and Projects)</td><td>Calculate CO based on LCL for Internal and External Evaluation and scale it 1 to 3.
<table>
<tr><td>Mark %</td><td>>50</td><td>>=40 and <=50</td><td><40</td></tr>
<tr><td>Score</td><td>Strong</td><td>Medium</td><td>Poor</td></tr>
<tr><td>Attainment</td><td>3</td><td>2</td><td>1</td></tr>
</table>
Net CO=40% Internal + 60% External</td></tr>
<tr><th colspan="2">INDIRECT TOOLS</th></tr>
<tr><td>Feedbacks (Students, Employers, Parents, Industries)</td><td>Calculate average of all CO based on feedbacks received and scale it 1 to 3</td></tr>
</table>

Table 2 : CO-Course Unit Formulation

	CO_1	CO_2	CO_3	CO_4	CO_5	CO_6
UNIT 1						
UNIT 2		√				
UNIT 3			√			
UNIT 4				√		
UNIT 5					√	
UNIT 6						√

Table 3: CO Calculation for Railway, Bridges and Tunnels Engineering (30040501)

Total 115 students	**CO_1**	**CO_2**	**CO_3**	**CO_4**	**CO_5**	**CO_6**	**Total**
Marks assigned	06	06	08	06	06	08	40
Marks Obtained	467	449	489	429	418	478	2730
Average	4.0609	3.9043	4.2522	3.7304	3.6348	4.1565	23.7391
Marginal Error (for $Z_{(0.05/2)}$	0.2710	0.2271	0.2203	0.2249	0.2183	0.2603	1.2658
LCL	3.79	3.68	4.03	3.51	3.42	3.90	22.47
UCL	4.33	4.13	4.47	3.96	3.85	4.42	25.00
L_1	38	49	57	59	57	33	47
L_2	30	29	0	0	0	27	24
L_3	47	37	58	56	58	55	44
CO Attainment (LCL)	63	61	50	58	57	49	56.18
CO Attainment (AVG)	68	65	53	62	61	52	59.35
Diff %	-6.67	-5.82	-5.18	-6.03	-6.01	-6.26	-5.33

Table 4 : CO Calculation for Concrete Technology (30040502)

Total 115 students	CO_1	CO_2	CO_3	CO_4	CO_5	CO_6	Total
Marks assigned	06	06	08	06	06	08	40
Marks Obtained	601	577	550	605	546	486	3365
Average	5.2261	5.0174	4.7826	5.2609	4.7478	4.2261	29.2609
Marginal Error (for $Z_{(0.05/2)}$	0.1327	0.1981	0.2758	0.1747	0.2122	0.2956	1.1094
LCL	5.09	4.82	4.51	5.09	4.54	3.93	28.15
UCL	5.36	5.22	5.06	5.44	4.96	4.52	30.37
L_1	73	40	50	57	44	35	49
L_2	0	21	25	0	0	32	10
L_3	42	54	40	58	71	48	56
CO Attainment (LCL)	85	80	56	85	76	49	70.38
CO Attainment (AVG)	87	84	60	88	79	53	73.15
Diff %	-2.54	-3.95	-5.77	-3.32	-4.47	-6.99	-3.79

Table 5 : CO Calculation for Analysis of Indeterminate Structures (30040503)

Total 115 students	CO_1	CO_2	CO_3	CO_4	CO_5	CO_6	Total
Marks assigned	06	06	08	06	06	08	40
Marks Obtained	536	478	472	508	440	348	2782
Average	4.6609	4.1565	4.1043	4.4174	3.8261	3.0261	24.1913
Marginal Error (for $Z_{(0.05/2)}$	0.2333	0.2317	0.2461	0.2258	0.2325	0.2378	1.2308
LCL	4.43	3.92	3.86	4.19	3.59	2.79	22.96
UCL	4.89	4.39	4.35	4.64	4.06	3.26	25.42
L_1	42	38	32	55	43	42	42
L_2	0	26	34	0	34	36	25
L_3	73	51	49	60	38	37	48
CO Attainment (LCL)	74	65	48	70	60	35	57.40
CO Attainment (AVG)	78	69	51	74	64	38	60.48
Diff %	-5.01	-5.57	-6.00	-5.11	-6.08	-7.86	-5.09

Table 6 : CO Calculation for Water Resources Engineering - I (30040504)

Total 115 students	CO1	CO2	CO3	CO4	CO5	CO6	Total
Marks assigned	06	06	08	06	06	08	40
Marks Obtained	536	442	340	465	411	182	2376
Average	4.6609	3.8435	2.9565	4.0435	3.5739	1.5826	20.6609
Marginal Error (for Z(0.05/2)	0.2053	0.2304	0.3495	0.2211	0.2097	0.2562	1.1513
LCL	4.46	3.61	2.61	3.82	3.36	1.33	19.51
UCL	4.87	4.07	3.31	4.26	3.78	1.84	21.81
L1	37	48	42	41	54	62	51
L2	0	32	20	31	0	0	20
L3	78	35	53	43	61	53	44
CO Attainment (LCL)	74	60	33	64	56	17	48.77
CO Attainment (AVG)	78	69	51	74	64	38	51.65
Diff %	-4.40	-5.99	-11.82	-5.47	-5.87	-16.19	-5.57

Table 7 : CO Calculation for Fundamentals of Environmental Engineering (30040505)

Total 115 students	CO_1	CO_2	CO_3	CO_4	CO_5	CO_6	Total
Marks assigned	06	06	08	06	06	08	40
Marks Obtained	629	521	490	585	483	359	3067
Average	5.4696	4.5304	4.2609	5.0870	4.2000	3.1217	26.6696
Marginal Error (for $Z_{(0.05/2)}$	0.1537	0.1817	0.3139	0.1930	0.2324	0.3942	1.2433
LCL	5.32	4.35	3.95	4.89	3.97	2.73	25.43
UCL	5.62	4.71	4.57	5.28	4.43	3.52	27.91
L_1	43	44	32	27	31	47	42
L_2	0	0	21	38	28	21	15
L_3	72	71	62	50	56	47	58
CO Attainment (LCL)	89	72	49	82	66	34	63.57
CO Attainment (AVG)	91	76	53	85	70	39	66.67
Diff %	-2.81	-4.01	-7.37	-3.79	-5.53	-12.63	-4.66

Table 8 : CO Calculation for Fundamentals of Basic Geotechnical Engineering (30040506)

Total 115 students	CO_1	CO_2	CO_3	CO_4	CO_5	CO_6	Total
Marks assigned	06	06	08	06	06	08	40
Marks Obtained	506	400	350	438	357	174	2225
Average	4.4000	3.4783	3.0435	3.8087	3.1043	1.5130	19.3478
Marginal Error (for $Z_{(0.05/2)}$	0.2121	0.2129	0.3561	0.2191	0.2806	0.3122	1.0969
LCL	4.19	3.27	2.69	3.59	2.82	1.20	18.25
UCL	4.61	3.69	3.40	4.03	3.38	1.83	20.44
L_1	53	59	41	43	30	64	50
L_2	0	0	20	36	26	0	17
L_3	62	56	54	36	59	51	48
CO Attainment (LCL)	70	54	34	60	47	15	45.63
CO Attainment (AVG)	73	58	38	63	52	19	48.37
Diff %	-4.82	-6.12	-11.70	-5.75	-9.04	-20.64	-5.67

Table 9 : Individual CO attainment for each course by LCL and AVG methods

Courses	CO1	CO2	CO3	CO4	CO5	CO6	Overall Class	Highest Students Level
30040501 (LCL)	Strong	Strong	Medium	Medium	Medium	Poor	Medium	L1
30040501 (AVG)	Strong	Strong	Medium	Strong	Strong	Medium	Medium	
30040502 (LCL)	Strong	Strong	Medium	Strong	Strong	Poor	Strong	L3
30040502 (AVG)	Strong	Strong	Medium	Strong	Strong	Medium	Strong	
30040503 (LCL)	Strong	Strong	Poor	Strong	Medium	Poor	Medium	L3
30040503 (AVG)	Strong	Strong	Medium	Strong	Strong	Poor	Strong	
30040504 (LCL)	Strong	Medium	Poor	Strong	Medium	Poor	Poor	L1
30040504 (AVG)	Strong	Strong	Medium	Strong	Strong	Poor	Medium	
30040505 (LCL)	Strong	Strong	Poor	Strong	Strong	Poor	Strong	L3
30040505 (AVG)	Strong	Strong	Medium	Strong	Strong	Poor	Strong	
30040506 (LCL)	Strong	Medium	Poor	Medium	Poor	Poor	Poor	L1
30040506 (AVG)	Strong	Medium	Poor	Strong	Medium	Poor	Poor	

Table 10 : CO Calculation for Weighted Course CO and Composite CO

Courses	30040501	30040502	30040503	30040504	30040505	30040506	Composite CO
Credits	4	3	4	3	3	4	40
Weighted CO (LCL)	56.82	71.63	59.54	49.52	64.47	45.21	56.82
Weighted CO (AVG)	52.66	66.33	59.36	49.63	62.99	45.39	52.66
Diff %	7.90	7.99	0.31	-0.21	2.35	-0.39	3.14

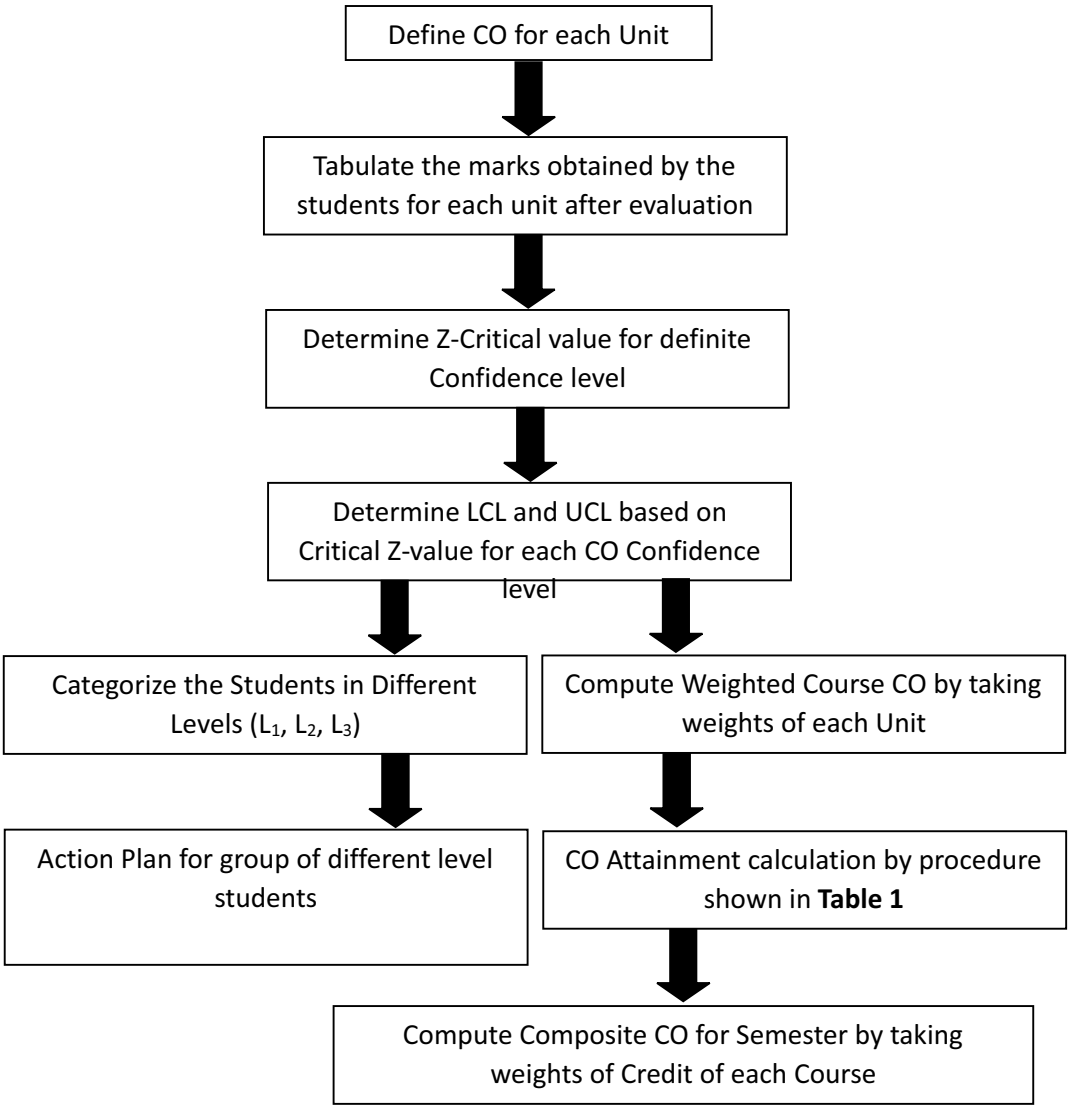


Fig. Flowchart showing procedure to compute CO and estimate CO attainment

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Professional Identity of Vocational Teachers in the 21st Century in Indonesia

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Abstract: This article focuses on the professional identity needs of vocational teachers in the 21st century in Indonesia. Challenges in the 21st century have changed and caused major changes for vocational teachers, while vocational teachers have heterogeneous characteristics, including learning experience, educational background, employment status, and other determinants. An important objective of this study is to analyze the proxies of professional identity of vocational teachers in the 21st century in preparing future vocational teachers. This research uses a descriptive qualitative approach. A total of 139 vocational teachers participated in describing the professional skills needs of vocational teachers for the future. The findings describe that (1) technology skills and ICT are defined as hard skills and apart from the 4Cs, literacy strengthening is needed to strengthen soft skills; and (2) vocational teachers need hands-on experience in the business world, industry, and the world of work (DUIKA). This study recommends that the professional competence of vocational teachers needs to be improved through self-development training and continuous professional development (CPD).

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Keywords: vocational teacher, professional teacher, professional identity, technology skills, real experience

1. Introduction

Teachers are important figures on the agenda in every country. The important role of teachers is to disseminate knowledge and produce competent human resources [1], [2] who contribute to the development of a country. More than that, the teacher is the last bastion of civilization, meaning that without the role of the teacher many people are lacking in ethics, lacking in morals, and low in character. As a result, damage occurs due to uneducated human behaviour. The teacher is a noble, superior, professional figure who builds good character with his knowledge, wisdom, enlightenment, and authority in guiding others. Thus, teachers are not limited to, teaching tasks, but also transporters for students.

Teachers in Indonesia are starting to lose “the meaning of teacher” as a transfer of knowledge (logos), due to a shift in orientation towards finance. The logos teacher values are commitment, love, and full awareness of working as a teacher, some teachers are hesitant in making decisions, but the best decision is to do work as a teacher with totality. The Logos values must be lived deeply (ethos) into everyday life (pathos) because the teacher is a roles model for students, we call it "ing madyo mangun karso" which means setting an example. Teachers who understand

and practice and put forward the values of logos, ethos, and pathos and then provide unlimited service are professional teachers.

The concept of teacher professionalism is important to be fully and comprehensively interpreted from the perspective of historical, political, and social contexts. This concept has undergone changes and developments from time to time, one of which is influenced by stakeholder groups [3]. More simply, the concept of professionalism is defined as success which refers to behavior in a particular job [4]. Boyt, Lusch, and Naylor, define the professional concept as a multi-dimensional structure of a person's attitudes and behaviour towards his work with high standards of achievement [5]. If it refers to professional goals, it is more to improve the quality of service.

Referring to the above professional understanding in the teaching profession, it is deemed necessary to improve services in achieving goals. However, the quality of teachers in vocational education is improved through mastery of the 4 competencies (pedagogic competence, personality competence, social competence, and professional competence) and 4 awareness (philosophical, theoretical, ethical, and technical). Vocational education teachers must master vocational philosophy, vocational theory, vocational principles, foundations, and assumptions in vocational education. For example, the pragmatism Reconstructionist strand has a great influence in achieving the goals of vocational education [6]. Vocational teachers must also master the theory of learning and student development. For example, the learning theory of cognitivism, behaviourism, constructivism, and humanism. Teachers must understand and apply the teachers' code of ethics in everyday life, [7]. Technically, teachers must collaborate with other teachers, between competence and integrated learning. Competence and awareness are important as professional teachers in vocational education in the future.

Finally, in finding the concept of becoming a professional teacher in vocational education, it can be found through the professional identity of the teacher that is formed. Researchers realize that the challenges in the 21st century are full of uncertainty, unpredictability, and require speed and accuracy in action [8]. Thus, the readiness of teachers to face change and the need to become professional teachers in the future is important to reveal. The focus of this research will be to explore the needs of professional teachers in vocational education in the future. This study was conducted by constructing the perceptions of professional teachers with more than 8 years of work experience, to predict future events.

2. Research Method

This study uses a qualitative descriptive approach [9]. Participants as many as 139 teachers in vocational education from various provinces in Indonesia, gave the perception of becoming a professional teacher in the future. The distribution of respondent data is presented in the following table.

Table 1 : Distribution of respondent by gender, province, and teaching experience

No	Respondent distribution	Nu (%)
1	**Gender**	
	Male	117 (84.17)
	Female	22 (15.83)
2	**Province**	
	Daerah Istimewa Yogyakarta	54 (38.85)
	Banda Aceh	2 (1.44)
	Banten	11 (7.91)
	Jawa Barat	3 (2.16)
	Jawa Tengah	2 (1.44)
	Jawa Timur	9 (6.47)
	Kalimantan	4 (2.88)
	Kepulauan Riau	4 (2.88)
	Lampung	6 (4.32)
	Nusa Tenggara Barat (NTB)	14 (10.07)
	Nusa Tenggara Timur (NTT)	14 (10.07)
	Sulawesi	7 (5.04)
	Sumatera	7 (5.04%)
	Jambi	1 (0.72)
	Bangka Belitung	1 (0.72
3	**Teaching experience**	
	7 Years	39 (28.06)
	8-17 Years	44 (31.65)
	18 - 27 Years	37 (26.62)
	≥ 28 Years	19 (16.67)
	Total	**139 (100)**

Note: Nu = Number

The response of the male sex was 84.17% and female sex was 15.83%. Distributed in 15 provinces, and the highest distribution is in Yogyakarta at 38.85%, Java Island at 10.07%, NTB at 10.07%, NTT at 10.07%, and Banten in fifth place at 7.91%, followed by other provinces. This distribution is sufficient for representing in Indonesia, where Yogyakarta with the branding as a "student city" and followed by the island of Java is the largest population, which is 56.10% in Indonesia. Another criterion is teachers teaching experience of more than

8 years as much as 72.94%. Thus, triangulation of sources of informants can be trusted or has high credibility.

2.1.Questioner Research

The research was conducted using a questionnaire designed in the form of google form. The questionnaire consists of 2 open statements that aim to give professional vocational teachers the freedom to express their perceptions. The research questions (RQ) are:

(a) RQ 1: What are the skills or identities professional needed by professional teachers in vocational education in the 21st century?

(b) RQ 2: What are the strategies of professional teachers in vocational education in enhancing professional identity in the 21st Century?

2.2. Data Analysis

Respondents' answers were grouped based on the theme of the research question, then grouped by gender, distribution of provincial data, and their teaching experience. The findings as a recommendation for professional teacher understanding in 2021, of course, will be different if the perception is the following year. However, these results illustrate the identity of professional teachers that is important to explore. The data are presented in tables and figures to facilitate understanding and are described based on the research findings.

3. Findings and Discussion

3.1.Skills or professional identity in Professional Teachers in Vocational Education in the 21st Century

Qualitative data in open statements that measure teachers' perceptions in vocational education about the "meaning of professional teachers" in the future have been categorized into two main aspects, namely hard skills, and soft skills which describe professional identity. The concept of hard skills and soft skills or life skills has been going on for a long time. However, the perception of teachers in vocational education finds several new meanings. The hard skills aspect consists of technology and ICT skills, technical competencies, entrepreneurial skills, and pedagogical skills. So far, teachers are only limited to developing pedagogic skills [10], and little in self-development in training activities and strengthening competencies. An interesting finding from hard skills is that 77.50% state that technology's ability is a very important skill. This is in line with core skills in the 21st century, namely information, media, and technology skills [11], [12].

Based on the analysis of the findings obtained, it is in line with the current learning challenges, namely the application of technology-based learning and technological change 4.0 in the industry, [13], [14]. This competency needs to be improved by teachers in vocational education in carrying out their profession as professional teachers, [15]. [16], Technical competence and entrepreneurial skills are perceptions expressed by teachers in vocational education in Indonesia. This means that vocational school teachers must develop skills according to their technical competence or expertise competence, [17], [18]. By mastering technical competencies, teachers will be more confident in practical learning in workshops or laboratories. The fact in the field that occurs is that teachers in vocational education are considered capable and competent for all learning in the field of engineering in schools. This assumption can reduce the professional meaning if the teacher doesn't certify technical competence. The main priority of becoming a teacher in vocational education is self-development through various trainings that are relevant to field competencies, [19], [20]. In addition, teachers in future vocational education must master entrepreneurial skills. This finding is in line with the purpose of holding vocational education, namely graduates who can work, become entrepreneurs, and continue to college (BMW).

Furthermore, the findings on the skills or professional identity of teachers in vocational education are pedagogic competencies, [21]. Vocational teachers must be able to master the management of learning. These competencies are interrelated with the use of ICT in learning. The teacher must be a learner, however generational differences between teachers and students must be recognized. Students are born in the era of technology and digitalization, if teachers do not adjust, develop and apply them to learning, conventional learning is not recommended by students. They feel bored and uninterested in teachers with old concepts. The results of perceptions about the main aspects and skills or professional identity of teachers in vocational education are described in fig. 1.

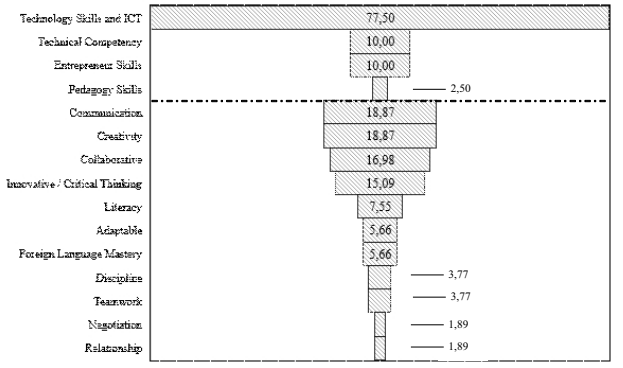


Fig. 1: Distribution of skills and professional identity of vocational teacher

The second aspect is the soft skills of professional teachers in vocational education. The results of the study revealed 11 skills or personal identities, including the 4Cs, namely communication, collaborative, creative, innovative, or critical thinking, literacy, adaptation, mastery of foreign languages, discipline, teamwork, negotiation, and work relations. The characteristics of learning in the 21st century are the 4Cs globally [22]. These skills are not sufficient for teachers in vocational education in Indonesia. Perceptions of vocational teachers are of the opinion that communication skills, creativity, collaboration, and critical thinking are positioned in the main cluster with 18.97% gains each; 18.87%; 16.98%; and 15.09%. 4Cs skills in vocational learning in Indonesia are contained in the stages of the learning process and become a characteristic of the new curriculum that has been implemented. The rest, the application of learning models with a scientific approach requires that 4Cs skills be included in it. Although vocational teachers in generations X and Y, have difficulty in implementing the 4Cs, they must be trained and trained on an ongoing basis.

The next professional identity is literacy mastery of 7.55%; adaptation by 5.66%; foreign language proficiency by 5.66%; discipline and teamwork by 3.77%; and negotiation and relationship by 1.89%. Although there are still many other professional identities theoretical, the size of the professional teacher describing the identity above is an important indicator that must be mastered at this time. Literacy skills are basic skills that must be mastered by a teacher, in the era of broad information, if you do not want to be left behind. Likewise, mastery of foreign languages is an important thing in communication. Discipline and teamwork are row models as vocational teachers, [23]. Teachers must be examples for their students and must be able to work together with other field teachers, after completing joint projects. While negotiations and relationships are the keys to success in achieving goals. Researchers are in line with the findings, that learning in the 21st century requires broader abilities. Thus, vocational teachers are ready to face global competition.

3.2.Strategies for improving the professional identity of vocational teachers

Professional teachers in vocational education should be as close as possible to the industrial world. Vocational teachers as facilitators or instructors who replace the industry to teach competencies according to industry needs [24, p. 0], [25]. This is a form of awareness of professional teachers who must be aware of the philosophy of vocational education, awareness of learning theory and student development in vocational education, awareness of ethics, and aware of the techniques. A vocational teacher who does not have experience or insight into the industrial world where graduates work, of course, makes the experience biased. Therefore, one of the strategies is the involvement of DUIKA in learning and the participation of teachers and students involved in work in the industry.

In Indonesian regulations, the qualification to become a vocational teacher is a bachelor's degree or diploma IV. However, many teachers who carry out learning practices do not meet the qualifications [26]. This is a form of loss to students. So vocational teachers must carry out self-development as a form of strategy in improving student competence.

The interpretation of the perception of professional teachers states that vocational teachers are required to do internships at DUIKA. Several strong reasons have been presented in fig. 2 including direct experience as a major consideration to become a vocational teacher. Researchers have the perception that vocational teachers never have direct experience as workers, while internship or OJT experience is not enough to contribute real experience. An important reason to convey is to improve skills. The researcher describes that teacher development with industrial development has quite far limitations. However, the demands of the industry are much faster than the demands of the vocational schools. There is a skill mastery gap if vocational teachers do not improve their skills. Some other considerations include technological change,

broad horizons, employment issues, culture, and management in the industry, integrity, and EQ. Of the eight perceptions of vocational school teachers to improve professionalism that teachers and industry have the same goal. Based on the results of the Based

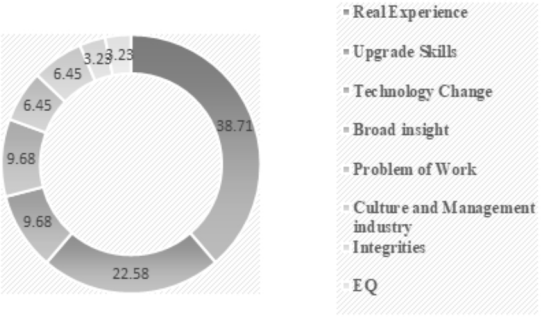


Fig. 2: Strategies for improving the professional identity of vocational teacher

Based on the results of the perceptual analysis of professional teachers in vocational, strategies in increasing self-development include direct experience of 38.71%, the highest among other identities. Vocational teachers have a strong belief that being a teacher must have experience, according to the field of work or develop skills in the vocational field. Furthermore, another strategy is the ability to upgrade skills by 22.58%. The concern of teachers in vocational education is that they will be abandoned if they do not immediately upgrade their skills, because of the obsolescence of the skills possessed in the past or present. Followed by other abilities are adopting the latest technology, broad insight, problems of work, culture and industry management, integrity, and emotional quotient (emotional intelligence).

Researchers claim that professional identity in the aspects of hard skills, soft skills, and life skills are integrated (integrated). Professional teachers in vocational education must have this identity in a complete and balanced way. Many perceptions have not been disclosed and show different variables in each country. However, a professional teacher begins with awareness, sincerity, loves his job, full of sincerity, has a high commitment. Thus, self-development in professional teachers is easy to improve.

4. Conclusion

The research findings describe the perception of professional teachers in vocational education in Indonesia, it is concluded that: (1) the professional identity of vocational teachers consists of ICT skills, technical competence, entrepreneurial and pedagogic abilities, while the identity of life skills consists of 4Cs skills, literacy, adaptation, mastery foreign language, discipline, teamwork, negotiation, and relationship. (2) self-development strategies for professional teachers include direct experience, upgrading skills, following technological changes, broad insight, problems of work, culture and industry management, integrity, and emotional quotient (emotional intelligence). Overall, the skills that emerge become the professional identity of vocational teachers. An important finding in this study is that ICT skills and hands-on experience-based learning are priority aspects for future vocational teachers.

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Women Entrepreneurship and Innovation in Higher Education: Opportunities and Challenges in India -A Review

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Abstract : In the recent years, Entrepreneurship and Innovation have taken new dimension due to increase in the globalization and liberalization. Women Entrepreneurs are the ones who start a venture or a business activity generating jobs for others. The three major factors that are playing important role in women entrepreneurship are : Firstly, internal factors such as individual's attitude towards risk taking or family encouragement, secondly external factors such as government support or reward system and finally the third factor is education & competencies.

According to 2016 report of Small Industry Development Bank of India (SIDBI), following southern Indian states such as Karnataka, Tamil Nadu, Kerala, Andhra Pradesh and Maharashtra have witnessed more than 50% of all women led small scale industrial units in India. The GDP of a nation increases as the women of the country progress in the field of entrepreneurship and innovation. Women have to be given equal chance as men in the field of entrepreneurship as most of the talented women end up with responsibilities at home. Despite facing a lot of socio-economic problems, women entrepreneurs and innovators have become successful. With a little more encouragement from the government , a change can be brought in how higher education institutions fosters entrepreneurship and innovation in women students and hence more and more women entrepreneurs are developed. To build the confidence and to promote innovation in women, a separate category of ranking for women institutions were included in Atal Ranking of Institutions on Innovation and Achievement (ARIIA) 2020, where a total of 674 institutions participated. The Indian higher education system has expanded at a fast pace by adding more than 20,000 colleges and more than 8 million students in the last decade and as of today, India has more than 800 universities. According to the AICTE 2016 report, there are over 10,500 engineering colleges and polytechnics in the country with an intake capacity of about 22,00,000 students. The conversion rate of women entrepreneurs are still very low, in spite of these many educational institutions. There are a lot of challenges with women entrepreneurship in India such as social obstacles , patriarchal society, lack of exposure, lack of confidence, lack of education facilities, no agenda in life, degree of financial freedom, risk taking abilities, lack of professional education, lack of interaction with successful entrepreneurship, lack of balance between family and career, lack of skills and finance in economically rich and poor women, no awareness about the capacities, problems working with male workers and so forth. This paper focuses on literature review of women entrepreneurship and Innovation in Higher Education in India and the key findings are highlighted.

Key Words: Women Entrepreneurship, Innovation, higher education

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1. Introduction:

Entrepreneurs are the change agents .The key recipe for new ventures is to demonstrate focus, passion and perseverance to keep progressing. Entrepreneurs are the ones who bring reform in the production through producing an old commodity in a new way or actually producing a new commodity. (Schumpeter. J.A, 1976)

Technological entrepreneurship means to use science and engineering to develop better products and services to delight the customers. It is believed that some geographical regions advance more than others due to their successful fostering of technological entrepreneurship leading to economic progress. (Schumpeter 1976, Venkataraman 2004) Globalization and industrialization took a new dimension when actually the development of the knowledge-based economy started since 1980s. This actually led to increase in the technological entrepreneurship. (Porter 1990) Etzkowitz in 1998 coined the term entrepreneurial university. In a study, MIT start -up companies have generated more than $240 billion worth of sales per year and also adding 1.1 million of new jobs for the US economy.

It is believed that engineers are technically very sound to create amazing products but lack the necessary business skills and entrepreneurial mentality. (Dorf and Byers, 2005) To bridge the gap of lack of entrepreneurial skills to the engineers all technical universities should include entrepreneurial courses that focuses on leadership skills, adjusting to constant change, contributing to innovation and being passionate about it.

Young females are more adjusting , accommodative and accept situations faster which makes them better entrepreneurs. It is believed that women generally are more patient and have perseverance which helps in dealing with labour and therefore labour troubles are rare in enterprises managed by women. Women are not less capable of men but there circumstances are different of those compared to men. Akancha explains in her work how women entrepreneurship has brought women from kitchen to boardroom table. (Akancha, 2018)

Rural development becomes the most important contributors towards nation strengthening. Women in rural areas are more focused on farming and house hold activities. (Qureshi, Khan, Uprit,2016)

Women in techno-entrepreneurship is a relatively unexplored area in India. Women entrepreneurs can contribute heavily towards the economic development of a nation hence it is imperative that technical institutions should provide entrepreneurship education to women or female students in particular. (Prodan, I., 2007)

There has to be a close collaboration between research centers, universities and companies. An entrepreneurship program should focus on the key factors of success that are Speed, adaptation, skill, knowledge and organizational approaches.

Technological parks helps in development of entrepreneurial ideas and together with university, government will help fostering entrepreneurial ecosystem. These technological parks are an amalgamation of research and business interests. Some of the functions carried out by these technological parks are not just limited to consulting, entrepreneurial training, raising funds but also Co-financing and building networks. (Prodan, I., 2007)

Entrepreneurship education is to be imbibed into the potential entrepreneurs during their adulthood and period of their degree pursuits. Some Entrepreneurs are born (Family business entrepreneurs) most others are created for the society through the systems instituted in the higher educational institutions. Currently, as part of NAAC (National Accreditation and Assessment Council) criteria 6, Governance, leadership and Management , the faculties are required to be trained on Entrepreneurship to handle subjects related to it. The institution are expected to define the program specific outcome , which is as per the specific criteria provided by the lead professional institute (institute of Industrial Engineers, USA)as given in the ABET criteria for engineering education. The Program Specific outcomes are framed by incorporating the feedback of all the stakeholders' including faculty members from inside and outside the institution, industry representatives, alumni and other higher education institutions.

A report published in 2019 by London business school indicates that the Total Entrepreneur Activity rate (between 18-64 age) for women in India is 12% and 17% for men. According to AICTE start up policy 2016, "An analysis of Indian entrepreneur profiles reveals that 32 years is the average age of entrepreneurs and that only 6 percent of them are women".

Ganesamurthy. V. S in his book on "Economic empowerment of women", defines women entrepreneurs are those who are economically independent individuals generating employment opportunities to others by being confident, innovative and creative along with balancing family dynamics and social life. (Ganesamurthy. V. S, 2007)

Kulkarni, N., et al (2016) in their work have mentioned about the Triple Helix model which is a framework in which there is emphasis on the role of university, industry and government interacting dynamically to create innovation for knowledge-based society. In a knowledge based society, innovation in university plays an important role. Innovation centres in universities can be established based on the structure discussed below.

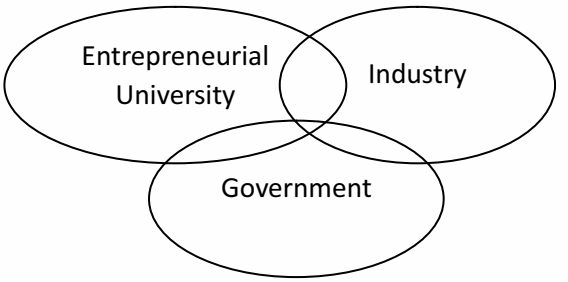


Fig. 1: Triple Helix Model [11]

Magadi, A. and Elshennawy, A.,(2004) in their work have highlighted four types of talent management systems in operation at university level namely 1.Strategy Management establishing the mission, vision, deployment infrastructure, 2. Process Management- focusing on all key processes to achieve operational effectiveness, 3. Project Management – helps in effective planning, organizing, implementing, controlling of all resources for successful completion of the innovative project and finally, 4. Individual Activity Management-provides a method of implementing continuous improvement of processes by flowcharting key processes to students.

Objective of this paper is to identify the various challenges and opportunities of Women Entrepreneurship in India and also to identify various reforms in higher education fostering women entrepreneurship in India.

2. Opportunities for Women Entrepreneurship in India:

According to 2001 Indian Census report, out of 402 million workers, 275 million are males and 127million females which equates to 51.7% of the total males and 25.6% of the total females are workers. The total female workers are half of male workers and out of this 87.3%most of the female workers are from rural areas. (Source: https://censusindia.gov.in)

In India, entrepreneurship is in the limelight in recent days and hence the entrepreneurship education has gained a lot of importance. Education system should focus on skill development and passing on relevant knowledge that encourages innovation, fosters job creation and combined together will lead to global competitiveness.

One can gauge the country's ability and its growth by looking at the size of the youth population. Recent reports on Indian age distribution indicates that India's youth population accounts for 67% of the overall population.(H.Plecher, 2020) What this means is that , if the right amount of entrepreneurial education is given to our youths in their early days ,India could become a Self Sufficient country (Aatma Nirbhar Bharat initiative by Sri. Narendra Modi Prime minister of India).The Indian higher education system has expanded at a fast pace by adding more than1000 universities and over 50,000 colleges. There are over 10,500 engineering colleges and polytechnics in the country with an intake capacity of about 22,00,000 students.(AICTE policy 2016)

To encourage entrepreneurship, many programs have been initiated such as Atal Ranking of Institutions on Innovation and Achievement (ARIIA), Startup India, Standup India, Digital India, Niti Aayog, Pradhan Mantri Kaushal Vikas Yojana (PMKVY) etc. (Kumar. S., Patrick. H., 2018)

At the university level, there are many initiatives taken to encourage students in their entrepreneurial journey by providing support such as Entrepreneurship Development Cell, Incubation Center, Venture capitalist involvement, design thinking lab etc.

Archana. M . S , et al (2019) in their work have depicted a progressive wheel that is simple to be adopted by institutions that are setting up the entrepreneurial eco system as shown in Figure 2 below.

As the popular saying goes "where there is a will there is a way", might apply to male students but for

female students , the saying goes as "Where there is a will there is a way in a suitable ecosystem". What this means is that women entrepreneurs in India would need a suitable environment around them that is conducive for exploring their entrepreneurial abilities. There are many small enterprises in India that are led by women entrepreneurs which are trying to mark their existence in the global market and the key to their success is the dedication, involvement along with hard working temperament making Indian women entrepreneurs unique. Many such women led firms are aspiring to become big money spinner seven though at the moment they are small.

A classic example of this would be Lijjat papad that is a revolutionary case that showed how business with social responsibility can be combined to produce brilliant results. This company was started by 7 women in 1959 with Rs.80 in Mumbai and is now worth around Rs.650 crores and they export to many countries like USA, UK, Middle East countries, Thailand, Singapore, Hongkong, Holland, Japan, Australia, and other countries. Their success can be attributed to their core concepts on business, family and devotion. These concepts are understood and uniformly followed by their member "sisters" through affection, trust and concern. Lijjat papad encourages the education of the children of their sister members by providing scholarships. This feeling of belongingness, unity, strong will power of achieving higher standards helps in achieving success. (http/www.lijjat.com)

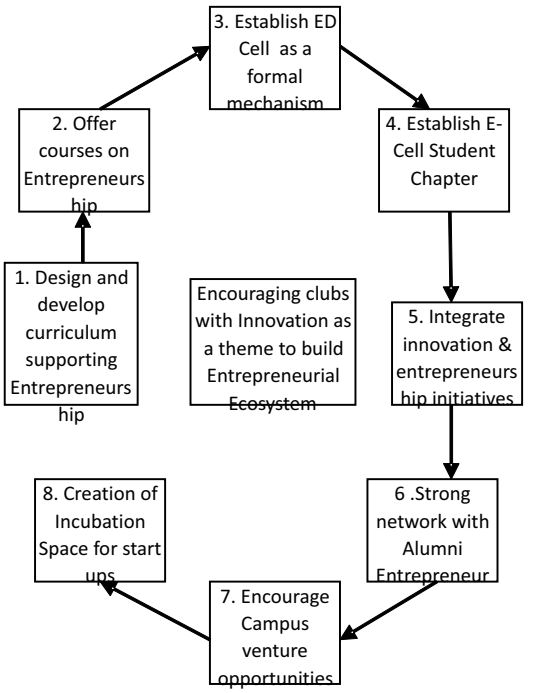


Fig. 2: Wheel of progress for Innovation and Entrepreneurship in Technical Institution [26]

Time after time it has been observed that women can form the center of economic reforms, through their hardwork building strong, vital organizations that are relevant to every other women, providing solutions through their experience that are viable and make an impact to the society.

Recently, the National Education Policy 2020 has been rolled out in India by the honourable Prime Minister Narendra Modi that talks about empowering youths with right skills for upcoming challenges and opportunities by making every human being intellectual, aesthetic, social, physical, emotional and morally strong. This New education policy will make the youths ready for changes throughout their career and not be confined to one domain .

The fundamental principle of the policy is based on Multidisciplinary and holistic education, Synergy in curriculum, flexibility to the learners to choose their own paths, Ethics , human and constitutional values, creativity and critical thinking, Life skills such as communication, cooperation, team work and resilience, focus on regular formative assessment for learning, outstanding research, use of technology, and most importantly regulatory frameworks.

The aim of the Nation Education Policy(NEP) 2020 is to increase the gross enrolment ratio from 26.3% to 50% by 2035. In order to maintain the quality of the education system, certain regulatory bodies are set up under Higher Education Commission of India(HECI). National Accreditation council (NAC) will be acting as a robust graded accreditation system. The new NEP will be helping in building necessary potentials, skills competencies for 21st century techno entrepreneurs who will be job creators.

Such government policies on education would drive some of the innovations and bring the collaborations between industry and universities. Industries interact with institutions and bring in the technology transfer through collaborations. (Kulkarni N., Shettar A., Atre M., 2016)

Financial security can be achieved by financial literacy to the women entrepreneurs and this can happen only through early education. Many financial

institutions like RBI, IRDA, NABARD educate rural women entrepreneurs on financial knowledge. About 3628 self-help groups have received financial assistance that have helped rural women become micro entrepreneurs. (Prabhu, 2004) Empowerment of these women entrepreneurs has to start at the institutional level.

Soni highlights how even today in the twentieth century , women sacrifices in India are glorified and hence many talented women get caught up with the family responsibilities ignoring their own growth. Many measures are taken to decrease the unemployment ratio of female workers that are more welfare oriented than development oriented which are not translating into self-employment. Soni states in her work that every Rs.1lakh of investment can generate jobs for 5-27 people. Further, she talks about some training programs for women self-employment such as small industries development organization(SIDO) and its chain of Small Industries Services Institute(SISI), National Extension Training Institute, the khadi &Village industries commission, the All India handlooms & Handicrafts Board, the Central Silk Board, the Coir Board etc. (Soni Kumari, 2012)

Other state level organizations such as Directorates of industries in the state governments, the state small Industries development corporation, state financial corporations and the district industries centers are actively involved.

In addition to these, there are also National programs such as the integrated rural development programs for husbandry, fishery, rural, cottage industries, commercial etc. Some National Scheme such as TRYSEM-Training of Rural Youth For Self-Employment. There are national banks that provide loans at lower interest rates for women entrepreneurs.

Further, women entrepreneurship schemes that supports and encourages women to explore innovation in Karnataka are Karnataka Mahila Abhivrudhi yojane (KMAY), Scheme for assisting women to take up training for job oriented program, Skill Development, 40 Stree Shakthi program, etc KSFC – Karnataka State Finance corporation supports women through its various programmes in terms of financial assistance. Many women's associations such as Ubuntu which comprises of AWAKE (Association of Women Entrepreneurs of Karnataka), COWE, EMERGE, KASSIA (Karnataka Small Scale Industries Association),WISE (Women's Initiative for Self-Empowerment),FKCCI (Federation of Karnataka Chambers of Commerce and Industry), and WEKAS(Women Entrepreneurs Karnataka Association) exists. The idea behind these women network is to encourage women in Tier II and Tier III cities in getting more business, facilitate marketing and vendor development. (Ratna Prabha, Chief Secretary to Government of Karnataka, 2017).

Many educated women take to medium and large scale industries where as some women who do not have formal training or education but have developed skills stick to small scale industries such as garments, weaving, pickles, dolls and handicrafts. Some women who are technically good venture into engineering, electronics, chemicals and pharmaceuticals, surgical instruments, furniture and poultry.

Many programs where Indian companies tie up with US universities such as “Upaya and MIT D Lab” to provide a hands on social business accelerators for early-Stage women entrepreneurs exist. Such programs are equipped with knowledge and connections to grow the business. Many technical training are combined with one on one consulting support with experienced team which helps in tackling the unique challenges female founders would face. These will open the opportunity for network with experts, investors and peer entrepreneurs. Some of these programs also provide seed money to make incremental improvements. These programs are focused on removal of unique barriers that women entrepreneurs face. Most important take backs from such programs are fundraising, investment readiness and leadership skills.

Singh in his work has identified some of the critical traits of women entrepreneurs such as assertive, persuasive, risk takers, hard work, diligence and perseverance. (Singh 2014) Bori in his work has explained how women groups have been very helpful in generating income through mutual helping attitudes. (Bori, 2017) Sharma et.al have highlighted that Self Help Groups (SHGs) have helped rural women to become financially independent. Sharma, Dua, & Hatwal, 2012) 2015 Mckinsey report states that India's GDP will increase by $700 billion in 2025 ,if at all more than 68million more women enter into non-farm labour force. Based on sixth economic census (EC) the 34.3% belong to agricultural activities, 31.6% belong to livestock, 29.8% and 17.8% belong to manufacturing and retail trade.

3. Challenges for Women Entrepreneurship in India:

It is said that about 87% of young women and men face challenges on unequal resources, education, healthcare, training and employment opportunities. For young women, these challenges are even more in spite of significant improvements in increase in primary school enrolments, not many have transitioned into secondary education, vocational training, non-formal education or entry into the labour market. (UNDP Youth Strategy 2014-17).

Government should accelerate the women based firms and help in stimulating the growth of small and medium sized firms. It should provide an environment that are friendly for the woman entrepreneur. Lack of Women Study Centers in Technical colleges has led to lower turnaround of women students taking entrepreneurial route. The government should provide support to women entrepreneurs at various levels. Most importantly, policies should be favorable to women entrepreneurs and institutions should encourage women entrepreneurship by providing the right education and mentorship.

Many entrepreneurship educational programs in the nation currently lack training women students on communication skills, problem solving skills, Team work, self-management and planning, Reputation, Productivity and Organization development. Educating about specific situations by women who have been successful would greatly help in the areas such as market positioning of the product , getting orders from retailers, village politics, religion and caste issues, fluctuating market conditions. (Pathak &Varshney, 2017)

It has been noticed that many women entrepreneur encounter issues on low self-confidence due to lack of education, lack of competence, finance related issues, family issues, societal issues and security. Further there are many other challenges for a women entrepreneur such as patriarchal society, lack of exposure, lack of role models, no agenda in life, degree of financial freedom, risk taking abilities, lack of interaction with successful entrepreneurs, lack of balance between family and career, lack of skills and finance in economically rich and poor women, no awareness about the capacities, problems working with male workers and so forth.

Entrepreneurship education is important for the following reasons : ideas and innovation creation, business ideas and innovation, entrepreneurship education program. (Cooperetal, 2004) Many entrepreneurship programs that are currently running in the country are missing the following aspects such as imagination, creativity and risk acceptance in business on the contrary, traditional views such as quantitative techniques are emphasized.

BM Naik (2019) in his work highlights about Indian universities where it falls short of achieving the world class ranking compared to foreign universities. Many Indian universities lack infrastructure facilities like research park, incubation center, start-up centers, research labs etc. Many foreign universities such as Stanford university has raised more than 3000 firms from ideation to a full fledge running firms and in turn universities receive royalty in millions of dollars back. This kind of an ecosystem is missing in Indian higher education system. Innovation and creativity has been ignored and not encouraged.

A paradigm shift in women entrepreneurship education is the need of the hour. It is said that by having proper research and innovation, most nations flourish. It is also said that India is spending 0.45% of GDP on research versus other countries who are spending 5%. Niti Ayog is trying hard to increase the funding for research. US stands as world's No.1 in power because of the good universities. USA universities year on year gets the higher score for patenting the ideas versus rest of the country. There needs a fundamental change in how Indian universities work. Only IIT Chennai has a research park associated with the university. Vakili. F, et al 2016 in their work have mentioned that there is an average and upward trend between entrepreneurship education and entrepreneurship development process. It is a challenge to define needs, gaps opportunities and education of active entrepreneurs. (Moghini & Ahmadpour Darayani, 2002).

A lot can be achieved by having a right mentorship program to encourage women students to take up entrepreneurial route while they are in campus and such mentor programs along with entrepreneurial ecosystem are currently not in place in the universities. Most of the problems of women entrepreneurs can be eradicated by proper education facilities to women, appropriate training, incentives, encouragement and social recognition.

4. Conclusion:

Women entrepreneurs play a critical role in synthesizing social progress with economic development of a nation . There is a lot of push from Government on the entrepreneurial education but nothing particular to women in higher education. The GDP of a nation increases as the women of the country progress in the field of entrepreneurship and innovation.

Women have to be given equal chance as men in the field of entrepreneurship as most of the talented women end up with responsibilities at home. Despite facing a lot of socio-economic problems, women entrepreneurs and innovators have become successful . With a little more encouragement from the government , a change can be brought in how higher education institutions fosters entrepreneurship and innovation in women students and therefore more and more women entrepreneurs are developed.Momentum is picked up with innovation as catalyst in the field of women entrepreneurship.

Transformation is seen when the education status of women is improved. Establishment of Women Study Centers in Technical colleges will be a strategic move to encourage women entrepreneurs. Some of the techniques these women study centers in higher education should adopt mentoring the young women students in entrepreneurship area such as:

1. Women who have taken up entrepreneurial route should be brought into university for workshops, conference, seminars to encourage the women students. Sharing their own entrepreneurial journey might motivate other women students.

2. Logical thinking in women should be encouraged in addition to skills in managing finance, risk taking, communication etc.

3. Case study based entrepreneurial courses should be launched that would provide clear guidelines that help women students to handle business situations. Example: Lijjat would be a good example on case study where a new member would learn from other sister members to understand the business aspects.

This calls for further study of Women Entrepreneurship framework in higher educational institutions in India.

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Car Race - an Engaging Interdisciplinary Python Based Project Activity

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Abstract: Here we present and evaluate a Calculus project using Python and parametrizations: the CarRace. Each student picks an image of a circuit and another of a car online to make the car perform a race in the circuit. Because every student gets a different circuit, they have different lines to parametrize. This is performed using a Python program. Beforehand students get an example of the code for a car performing a circuit and must adapt it to their own project.

This project was posed to a total of 346 engineering students over the course of 3 years. To evaluate the effectiveness of the project, we surveyed all participating students and 120 of them answered. The feedback from the students was mostly positive. It was engaging for students to make this project. They liked to see an immediate application of Mathematics. It helped them understand the subject better and they found it interesting to combine Python and Mathematics. At the same time, they also develop their critical thinking and problem-solving skills.

Keywords: python, interdisciplinary, engineering students, project, coding, calculus.

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1. Introduction

The relevance of coding is widely spread. Sullivan and Melvin (2016) state that writing code is fundamental to Science Technology Engineering and Mathematics (STEM) students so they can be literate 21st century scientists. According to Tranquillo (2015) programming is in the curricula of nearly all engineering departments. Also, STEM employers advise students that it is crucial to know how to code, to develop interdisciplinary skills, and to learn to work intensively on a project (Cline et al., 2020; Dorff, 2014). "Computer programming and mathematical algorithms are natural partners in the development of programming skills, logical thought, and a deeper understanding of mathematical concepts" (Jones and Hopkins, 2019). Rich et al. (2014) studied the impact that learning computer programming has on the way students approach mathematics and found that it leads students to get better context, applications, structure, and motivation for mathematics, which are long-lasting apprenticeships. According to Patil and Kale (2019), learning problem solving skills using computer programming in the first year of the degree is important. Moreover, computer aided topics serve to increase interest and promote thinking (Clark,1999).

Project Based Learning (PBL) is an innovative approach for Integrating 21st century skills (Pawar, Kulkarni and Patil, 2020) like: creativity, communication and presentation, time management, self-assessment, group participation, leadership, and

critical thinking skills. According to Chen, Kolmos et all (2019) PBL has been widely adopted in engineering education during the last 40 years because of its effectiveness in improving students' academic knowledge, teamwork skills, communication skills and leadership. PBL not only improves problem-solving abilities but also promotes the development of critical thinking skills, involvement in the team, communication skills, comprehension of reflections, and all of the above mentioned as well as understanding and applying the course content, according to Hegade (2019). For example, Cline et al. (2019) presents several examples of projects for introductory, intermediate, and advanced classes of mathematics. According to them "Projects allow students to recognize that they are capable of using mathematics to investigate complex scenarios. In the end, they are an important part of a student's mathematical growth, helping them to become capable and independent problem solvers."

Regarding the study of Mathematics using a computer, many topics in Mathematics can be taught using computer activities (Mackiw, 1996). For example, in a survey of Algebra students, they favoured computer learning approaches in many different ways (Clark et al. 1999). And according to Hodgson (1995) the use of a programming language led to a deeper understanding and interest in Mathematics.

We chose to use Python as the programming language since it is the one that the degree coordinator considers to be transversal to the whole degree. Moreover, it is widely used as a programming language when mathematics is to be associated and used in the outside world. For example, to Schueller (2019) Python is a ubiquitous programming language, present in academy and in industry. So, he utilised Python programming language to solve a project using mathematics. The inverse is also interesting, utilizing mathematics to teach how to code (Langtangen, 2009). He chose Python as the programming language because it combines remarkable expressive power with clean, simple, and compact syntax. Phyton is even used at a high school level in order to code topics of Algebra, Calculus and Statistics (Saha, 2015). Python is also used as a means to introduce problem-based learning and promote active learning in the classroom (Jeyamala, 2020). Hutchison (2021) also integrated Python into an undergraduate mathematics course.

Programming in Python also fosters Active Learning. We, like Namratha et al. (2018), promoted the interaction among students when they were making the project in order to get an active process of learning. Jeyamala and Abirami (2020) also successfully used Active Learning to teach Python.

The CarRace is especially relevant because it includes coding, which is very important to students nowadays. Additionally, it promotes critical thinking, and it is an opportunity for project-based learning. We know that projects allow students to develop many different skills, as well as to engage in active learning which deepens the understanding of the subject and also to develop problem solving skills. The project allows students to learn Mathematics using a computer which gives them a deeper understanding and interest in Mathematics. This project is especially interesting because it mixes it all.

In the next chapter we will show the context in which the project arises. Then, we will explain the project itself. After that, we lay out the research question and the methodology used to collect data. Finally, we will draw our conclusions.

2. Context

In the academic years of 2017/18, 2018/19 and 2019/20 the students of Mathematics Applied to Engineering course of the Computer and Multimedia Engineering degree of a Polytechnic Institute were given a project. This course was a traditional Calculus course for the first year, first semester; the syllabus was differential and integral calculus in IR. That semester, Parametrizations was added to the syllabus. In 2017 the course had 110 students, in 2018 it had 113 students and in 2019 it had 123 students. Respectively, 95, 86 and 99 accomplished the project. The project counted for 10% of their grade, was compulsory and had a minimum grade of 8 out of 20 points. There were 4 classes, two of which had a professor, and the researcher taught the other two. The class size was decided, as usual, by the course manager.

3. Car Race – the project

The goal of the project is to make a car perform a trajectory on a circuit (see Figure 1). Each student searches online for an image of a circuit (or creates it) and then registers it on a page (a wikipage on Moodle) that we called Patent Registry. This way there are no two students using the same circuit, meaning that the

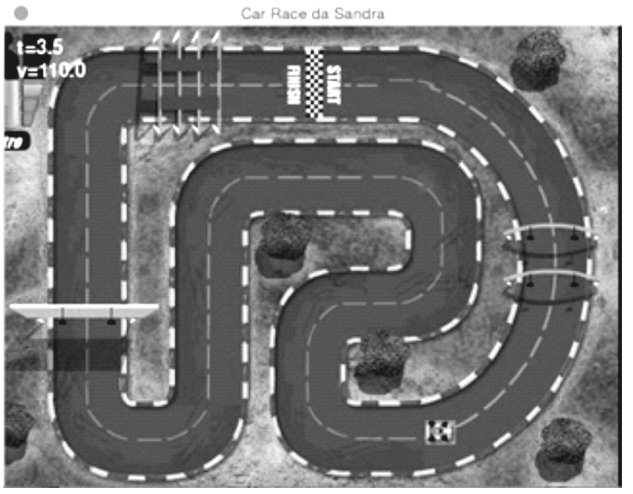


Fig. 1 : Screenshot of a car performing a trajectory on a circuit. The example given to students.

cuit is different to every student. Each student then picks an image of a car. The goal is to make the car perform the trajectory of the circuit using parametrizations. To this end the teacher provides the class with a Python file where a car performs a trajectory: the example code is on Appendix. The Python behind this is quite trivial, the teacher explains how it works in class in 30 minutes and students start their own work in the following 60 minutes. Students need to do little more than to adapt the parametrizations that make the car perform their own race. They perform lines, circles, parabolas, ellipses, etc.

Students only need to take their own laptop with Python and Pygame installed to the class where the example is explained (this is not a problem - every student has their own laptop and they have a programming course where they use Python and Pygame). The circuit must contain at least a line or a parabola and at least a circle or an ellipse to make students learn how to parametrize those kinds of curves. At the end, the student should present the files of the car, the circuit, the Python code and a video of the car performing their race (this may be recorded with mobile phone). Since the project is different for each student, usually students don't need to present it. We only discuss them if we have any kind of suspicion (it has never happened thus far).

The project receives a mark of 10 points if the car runs inside the road. Another 4 points if the velocities are adequately adapted, i.e. runs faster in lines and slower in curves. Another 2 points if the velocity is displayed on the screen. Another 2 points if the car adapts its direction to the trajectory direction. And finally, the other 2 points are afforded to any extra features that the student decides to include.

The aim of the project, more than to evaluate, is to show students an immediate application of mathematics to a natural problem. It is also meant to make Python a transversal tool in their training. Additionally, we look for an engaging problem that students enjoy working on.

4. Data collection

The research question is: Is it possible to create an engaging, multidisciplinary, and effective project to teach mathematics for engineering?

The methodology used was an anonymous survey available to all the 110+113+123=346 students and answered by 26+51+43=120 students.

According to Table 1, students' answers to the question of whether the CarRace project made them pleased or displeased, showed that around 75% felt pleased or highly pleased.

Table 1: Answers to "Working on the CarRace project made me:"

"Working on the CarRace project made me:"	2017	2018	2019
N	26	51	42
Highly pleased	27%	6%	33%
Pleased	42%	68%	48%
Indifferent	16%	22%	17%
Displeased	15%	2%	25%
Highly displeased	0%	2%	0%

According to Table 2, around 50% of the students believed that the project helped them understand the subject better.

Table 2 : Answers to "It helped me better understand the subject:"

"It made me better understand the subject:"	2017	2018	2019
N	26	51	43
Totally agree	4%	4%	21%
Agree	50%	47%	42%
Indifferent	19%	23%	26%
Disagree	23%	24%	7%
Totally disagree	4%	2%	5%

Around 50% of respondents think that using Python didn't increase difficulty to the project (see

Table 3).

Table 3. Answers to "Using Python didn't lead to an increased difficulty:"

"Using Python didn't increase difficulty:"	2017	2018	2019
N	26	51	43
Totally agree	12%	24%	23%
Agree	40%	46%	28%
Indifferent	32%	16%	19%
Disagree	16%	12%	23%
Totally disagree	0%	2%	7%

Very few students disagree that it is important to have Python as a transversal tool in their degree, as can be seen in Table 4.

Table 4 : Answers to "It makes sense to me to use Python transversally in my degree, therefore also in curricular units of mathematics:"

"Using Python transversally in graduation:"	2017	2018	2019
N	26	51	43
Totally agree	32%	26%	30%
Agree	44%	45%	42%
Indifferent	24%	25%	19%
Disagree	0%	2%	7%
Totally disagree	0%	2%	2%

Around 80% of respondents agree that it is important to see an immediate application of mathematics (see Table 5).

Table 5 : Answers to "It was interesting to see an immediate application of Mathematics in CarRace: "

"An immediate application of Mathematics:"	2017	2018	2019
N	26	51	43
Totally agree	27%	22%	35%
Agree	61%	56%	49%
Indifferent	4%	18%	12%
Disagree	8%	4%	4%
Totally disagree	0%	0%	0%

As shown in Table 6, nearly 80% of respondents globally classify the existence of CarRace as positive.

Table 6 : Answers to "Globally I classify the existence of the CarRace project as:"

"Globally I classify the existence of the CarRace project as:"	2017	2018	2019
N	26	51	43
Very good	23%	12%	30%
Good	61%	62%	58%
Indifferent	8%	22%	9%
Bad	8%	4%	0%
Very bad	0%	0%	2%

As qualitative feedback students wrote: "I really loved seeing mathematics be used for something useful, I gained interest to learn more about the subject."; "Good initiative to reconcile UC knowledge in addition to not being too complex, though it still requires dedication and reasoning on the part of the student."; "It makes us debate with other people and research about Python and this leads us to understand and to be more comfortable both with the professors and with the classmates."; "It helped a lot to understand the subject of parameterizations"; "It made me understand more about the subject, in addition to better preparing me for the exam/test. And I really enjoyed seeing my project completed at the end. It was also nice to have the option of being able to choose the map and the icon, as well as the path where he was racing, without having to be the same as the whole class."; "The CarRace concept is an interesting adaptation of parameterization and a good introduction to the theme of autonomous vehicles".

Students were exceptionally committed and

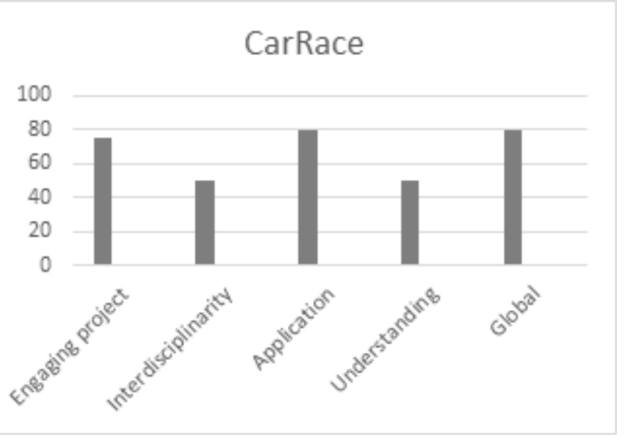


Fig. 2 : Percentage of students who agree that the project is engaging, positive, and interdisciplinarity; that it is positive to se an application of Mathematics; that it deepens understanding, and the global classification as a positive project.

extremely interested in doing the project. They were all paying attention. Students were developing several skills like critical thinking, involvement in the team (after this phase they interact with each other, seeking support), communication skills, problem solving skills, independence, self-learning, etc.

In conclusion, to answer the research question: Is it possible to create an engaging, multidisciplinary, and effective project to teach mathematics for engineering? We can analyse Figure 2.

Regarding "Is CarRace an engaging project?", around 75% of respondents felt pleased doing it.

Regarding whether students perceive its interdisciplinarity as important, around 50% states that using Python didn't increase the difficulty of the project and nearly all students perceive the inclusion of Python transversaly in the degree as important.

Nearly 80% agree that it is important to see an immediate application of mathematics.

Regarding the question of whether it gives students a deeper understanding of the subject, 50% believe that the project made them better understand the subject.

As a global classification nearly 80% classify the CarRace project as a positive activity.

With the qualitative data we can see that: students appreciate to see applications of mathematics; CarRace helped students to gain interest in the subject; CarRace had a good balance of difficulty; it fosters relationships among fellow students and among students and teachers; it deepens the understanding of the subject; and students enjoyed the project. Thus, we can conclude that it is an engaging, multidisciplinary, and effective project.

5. Conclusions

In the first semesters of 2017, 2018 and 2019 a CarRace project using the subject of parametrizations was proposed to 346 computer engineering students wherein each student picked an image of a circuit and an image of a car and made the car perform a race on that circuit. Thus, every student had a different trajectory to parametrize. This was performed using a Python program. Students had access to an example program and adapted it to their own circuit. The project was accomplished by 280 students, which make up 81% of the participating students.

The research question was “Is it possible to create an engaging, multidisciplinary, and effective project to teach mathematics for engineering?” A survey was available to all the students and 120 answered it. More than 75% of respondents stated that they enjoyed doing the project. So, we can conclude that students enjoyed the project.

Around 50% didn't find increased difficulty by doing the project in Python. Nearly all students believe that it is important to have Python transversally present in their degree. Around 80% state that is relevant to see an immediate application of Mathematics. Thus we conclude that students find it relevant to have this interdisciplinarity through the project.

About 50% believe that CarRace helped them learn the subject better. And the global assessment of the project was, according to 80% of respondents, that it is a positive activity.

This project made students develop several skills like critical thinking, teamwork, communications skills, problem solving skills, independence and self-learning.

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Appendix: CarRace code

```
# Import pygame module
import pygame, sys
from pygame.locals import *
from math import cos, sin, sqrt
# inicialization of pygame module
pygame.init()
# creation of a window
width = 532
height = 410
size = (width, height)
window = pygame.display.set_mode(size)
pygame.display.set_caption('Car Race da Sandra')
```

```
    #window'name
#At this window the (0,0) point is at upper left corner
#and (532-1,410-1) = (531,409) is at the lower right
    corner.
# number of frames per second
frame_rate = 30
# clock to control frame rate
clock = pygame.time.Clock()
# read an image
speedway = pygame.image.load("speedway.jpg")
car = pygame.image.load("car.jpg")
#Inicializes time
t=0.0
############################
#To write the time in the top of the window
font_size = 25
font = pygame.font.Font(None, font_size) # default
    font
antialias = True # suavization
WHITE = (255, 255, 255)# color (values of Red,
    Green, Blue between 0 and 255)
############################
##Example adjusted to circuit:
def parametrization (t):
  if t==0:
    result=(230,40)
  if 0<t<=0.5:
    result=(230+250*t,40)
  if 0.5<t<=3.64:
    result=(355+110*cos(-2+t),190+150*sin(-2+t))
  if 3.64<t<=4:
    result=(347.4-250*(t-3.64), 339.6)
  if 4<t<=4.4:
    result=(250, 340-250*(t-4))
  if 4.4<t<=4.8:
    result=(250+250*(t-4.4), 230)
  if 4.8<t<=5.2:
    result=(355, 230-250*(t-4.8))
  if 5.2<t<=5.6:
      result=(355-500*(t-5.2), 120) #around twice
    velocity
  if 5.6<t<=5.9:
      result=(160, 140+500*(t-5.6)) #around twice
    velocity
  if 5.9<t<=6.4:
    result=(120+450*(t-5.9), 340-(450*(t-5.9)**2))
    #around twice velocity
  if t>6.4:
    result=(0,0)
  return result
###################################
#Main cycle of the game
while True:
  time = font.render("t="+str(t), antialias, WHITE)
  window.blit(speedway, (0, 0))
  window.blit(car, parametrization(t))
  window.blit(time, (10, 10))
  pygame.display.update()
  clock.tick(frame_rate)
  t=t+0.1
    for event in pygame.event.get():
     #To quit...
     if event.type == QUIT:
       pygame.quit()
       sys.exit()
     #When to click on any place, the time restarts on
     t=0
     # event mouse click left button (code = 1)
##   elif event.type== pygame.MOUSEBUTTONUP
     and event.button == 1:
##       t = 0
```

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Sustainable Engineering higher education in Oman-lessons learned from the pandemic (COVID-19), improvements, and suggestions in the teaching, learning and administrative framework.

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Abstract: This research study has investigated the challenges faced due to the pandemic (COVID-19). This paper further provides recommendations that can be adopted by academics, learners, and administrators to make the education system more robust and sustainable. The impact of the COVID-19 pandemic can be felt in various fields across the world including higher education. The closure of face-to-face (FtF) learning in educational institutions worldwide has impacted over 95% of the world's student population. Therefore, in wake of this, many institutions have quickly adopted to offer complete online teaching and learning in a very short period. However, such a quick transition has raised several challenges. 1) What are the challenges encountered by academics and their readiness to adapt to the rapid remote learning transition? 2) What are the challenges encountered by learners (students), and their readiness to adapt to the rapid remote learning transition? 3) What are the recommendations for strategic planners or high-level administrators in institutions to tackle such pandemic risks effectively in the future? To address research questions mixed methods are used. A qualitative questionnaire survey is framed by an extensive literature review to understand the perceptions of academics and learners. A total of (n=525) academician samples and (n= 1460) student samples have been collected. The academic and learner's perceptions are analyzed by estimating the Pearson correlation coefficients. The mean and SD values based on academic rank stood at 3.01±0.96, and by experience stood at 2.96±0.98. Similarly, learner's perceptions stood at 2.67±0.95. Keywords: FtF (Face to Face); problem-oriented and project-based learning (POPBL); LMS (Learning management system); emergency remote teaching (ERT); emergency risk (COVID-19): Standard deviation (SD).

Declarations: NA

1. Introduction:

Observing the current global crisis turned on due to the pandemic (COVID-19 virus) situation seen around the world has enforced various industries to adopt different methods of work styles to keep pace with the regular life course. The number of COVID-19 affected cases globally has reached near to nineteen million (as of today) [1] and still seems to be increasing exponentially in some countries like the USA, Brazil, India, and most of the European countries including the UK. Although there are concerns that the COVID-19 data by some countries is not accurate never the less the effect is seen to be

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predominant. Therefore, the current increasing trend shows that the governments are likely to continue to lock down and could ask their respective citizens to follow social distancing, wearing protective masks, and other necessary precautions until some better updates are seen such as vaccine development or any substantial treatment for the COVID-19 virus. The impact of the COVID-19 virus on the commercial market is seen to be enormous and its correct estimate is still yet to be known which may take few more months to analyze if the COVID-19 virus and death rate gets controlled. It is predicted that some countries may take months to recover from the ongoing economic crisis and return to the regular life course. The Education sector is also not an exception to escape from the ongoing pandemic. However, It could have been a hotspot for the spread of the disease if no action would have taken at the right time affecting the millions of innocent students and the associative staff. Most of the universities globally have to suspend face-to-face (FtF) studies as an immediate interim to contribute to avoiding the fast spread of the COVID-19 virus. As a result, many challenges are continuously raising in providing continuing education along with the best learning experience.

Engineering studies are indispensable education in society. Intellectual skills and knowledge learned through these studies play a very vital role in building and transforming our society either it be in infrastructure, power, environment, and technology almost every discipline, engineers are required. Generally, any education system including engineering involves two major complementary processes to define the overall objective of the education system. 1) the learning process and 2) the teaching process. Both processes require good synchronization to achieve the learning outcomes of the enrolled engineering program studies. [Mobarak, H.M, 2016] However, it is often observed that there exist's mismatches between these two processes resulting in the poor performance or loss of the potential excellent engineers for our society. Further, Engineering studies also require good hands-on practice by performing experimentation, analysis of the experimental data, research, and innovation. Several innovative and teaching methodology solutions are proposed globally by various academicians to increase the effective learning of engineering students. [Wilson-Lopez, et.al, 2020] studies described the significance of adopting argumentation-based pedagogies in engineering education and how it impacts and improves the student learning experience and engagement. [Lehmann, M, et.al, 2008] research studies have considered both problem-oriented and project-based learning (POPBL) as the best methods in developing sustainable engineering education. [Karabulut-Ilgu, et.al, 2018] review studies have revealed that flipped classroom (or) blended teaching methodologies have been gaining popularity in both learning and teaching methods since 2012 in the engineering pedagogy. Further, recent research conducted by [Alomari, M, et.al, 2020] has investigated the effect of human factors on the effectiveness of the learning management system which is based on blended teaching methods. This study has developed an updated framework to enhance the learning user experience in blended teaching methods.

The engineering discipline consists of a wide range of topics covering the broad education spectrum in almost, all the fields of science and technology. Despite its vast education spectrum, the fundamental teaching methods used in course content creation will contribute to the six principles of the engineering education objectives as defined by Bloom's Taxonomy of Educational Objectives [Felder, R.M, et.al, 2004]: 1) Knowledge 2) Comprehension 3) Application 4) Analysis 5) Synthesis and 6) Evaluation. The regular approach or methods used in achieving these objectives is currently becoming questionable due to the current COVID-19 pandemic. Most of the universities across the globe have started to use effectively their respective E-learning systems to keep students engaged or seem to consider remote learning as the only viable temporary option to sustain in the education industry. Nevertheless, unpreparedness to predict such risks could occur in the educational system or inability to handle such risks effectively upon occurrence needs to be thoroughly analyzed. So far, the priority risk factor in an education institution considering the student perspective is based on student learning experience, student retention, and student success factor. Almost none of the educational institutions might have considered the readiness in tackling such risks upon occurrence. Therefore, an updated rigid educational deliverance methodology needs to be investigated that can not only handle such emergency risks but also improves and make the model robust.

In engineering higher education the teaching methodology mainly comprises an outcome-based

instructor-centered approach, a practical hands-on approach, a problem-based, and a project-based approach. Although usage of E-learning platform tools such as learning management systems (Blackboard and moodle), online lecture conference tools or video recording seems to be an alternative option to compensate for the outcome-based instructor-centered approach, (POPBL) approach. But there arise several challenges that are being prevailed in the deliverance of the practical hands-on experience. As most of the engineering courses have a lab component that provides the students with co-relating the theoretical concepts taught during the class, implementing and testing the design process, evaluating and finding solutions, troubleshooting skills, innovation skills which are the core parts of the program learning outcomes. Although there exists literature on online engineering education, to the best of our insight there has been no comprehensive analysis conducted on the challenges faced by academics and learners who were primarily dependent on face-to-face (FtF) teaching and learning before the pandemic. Furthermore, depending on the obtained survey results few recommendations are suggested to administrators that can improve overall teaching and learning experience and also can sustain to pandemics. [Syauqi, K., et.al, 2020] research study discusses the learner's perceptions only due to pandemic. [Opriș, I., et.al, 2020] research study discusses the pandemic challenges and opportunities focusing mainly on particular engineer discipline. Another research study [Revilla-Cuesta, V., et.al, 2021] discusses the teacher's perceptions only due to pandemic. More importantly, little to no literature exists so far documenting the teaching and learning practices adopted in the sultanate of Oman. This paper can be extremely helpful in contributing to the world engineering education practices database. Therefore, to address the above-raised gaps the following research questions are considered:

RQ1: What are the challenges encountered by academics and their readiness to adapt to the rapid remote learning transition?

RQ2: What are the challenges encountered by learners (students), and their readiness to adapt to the rapid remote learning transition?

RQ3: What are the recommendations for strategic planners or high-level administrators in institutions to tackle such pandemic risks effectively in the future?

To investigate the above-presented research questions a survey is conducted in technical colleges and universities of oman specifically focusing on engineering academics and students. The outcomes of this research are not only addressing the engineering discipline but can also be considered in general and even the entire education system as a whole. COVID-19 emergency risk is considered to be a global pandemic by the united nations. Further, providing quality education is one of the seventeen sustainable goals developed by the united nations which seems to be at risk due to the current ongoing health crisis [www.undp.org, 2020]. Therefore, the current education system needs upgrades to tackle such emergency risks effectively in the future and thus contributing to UN sustainable development goals.

2. Literature review and methodology

2.1. Literature review

The popularity of the remote learning approach has seen tremendous growth by the availability of various MOOCs (massive online open courses) platforms such as edX, Coursera and Udacity, etc. specifically from the developing and under-developing countries where the accessibility to quality education and resources are limited [Ch, S.K. and Popuri, S., 2013]. The second prime factor witnessed for gaining popularity is flexibility, expediency for learners, and usage of technology for auto-grading, where the enrolled students can instantly observe their performance and take necessary feedback for continuous improvements. The third factor is getting certified for an already qualified person showing continuous learning, commitment in their respective core areas which are welcoming attributes for an employer. On the other hand, E-learning challenges particularly focusing academics perspectives are attributed to five subcategories and they are 1) Learning Style and Cultural Challenges 2) Pedagogical E-learning Challenges 3) Technological Challenges 4) Technical Training challenges and 5) Time Management Challenges [Islam, N. et.al, 2015]. Considering both sides of a coin, the transition to a remote learning approach is seen inevitable during emergency risk circumstances such as COVID-19 and also can be a guiding experience for future potential risks (if any) in higher education institutions. Various challenges have been raised at the higher educational institutions during the transition of teaching from an Outcome-based instructor-centered /blended teaching approach to a complete remote learning approach. Specifically highlighted concerns are related to

faculty readiness in using online teaching tools, necessary infrastructure availability at both ends (academicians and students), assessment methods to fairly meet the course learning outcomes, and challenges prevailing in delivering lab courses/sessions [Sahu, P., 2020].

A mixed approach (qualitative and quantitative) is used in developing the survey questions and analysis of survey data to conclude. Table 1 lists the articles reviewed to developing the qualitative survey upon which the academics would majorly relate the quick transition experience. And Table 2 is in perspective with the learner's readiness and expectations.

Table 1: Academics survey questions using the qualitative approach.

Articles reviewed	Major findings summary	Construct and the statement question used in the survey
[Albrahim, F.A., 2020], [Adnan, M., 2018], [McGee, P., Windes, D. and Torres, M., 2017], [Rhode, J. et.al, 2017], [Salehi, N. e t.al, 2017], [Kenzig, M.J., 2015].	The technological skills (professional development) of the faculty play an important role in content development in teaching online.	Faculty competency Readiness in the use of technology (Item no: 1) Q1: I have competent technical skills to deliver an online course.
[Hsiao, C.C. , et.al, 2019], [Schophuizen, M , et.al, 2018], [Gul, S., et.al, 2017],	1) Assessment methods are different from face-to-face (FtF)/ flipped classrooms in contrast to online teaching. 2) a thorough knowledge o f the mapping of the learning outcomes is required.	Awareness of assessment methods and mapping learning outcomes (item no:2) Q2: I have a complete awareness of various assessments suitable to deliver my course online. Q3: I have competent knowledge of mapping course learning outcomes suitable for online teaching.
[Kebritchi, M., et.al, 2017], [Zayas, N.L., 2011], [Worley, W.L , et.al, 2009],	Timing constraints; it is hypothetically believed that online teaching takes more time and effort than regular Face to Face teaching (FtF)	Time management (Item no: 3) Q4: I have enough time to transit my courses from face-to-face (FtF)/flipped method to completely online.
[Brinthaupt, T.M, et.al, 2011], [Grant, M.R., 2011], [May, G.L, et.al, 2003],	Teaching styles; the regular teaching methods used during face-to-face (FtF) teaching do not work effectively in online teaching.	Teaching Styles (Item no: 4) Q5: I have competent knowledge of different teaching style practices used in online teaching mode. Q6: I have supported community and resources to learn the best online teaching styles.
[Altalbe, A., 2018], [Potkonjak, V, et.al, 2016], [Valdez, M.T. , et.al, 2015], [Valdez, M.T , et.al, 2013], [Valdez, M.T, et.al, 2011]	Delivery of remote lab courses in engineering is possible by Virtual labs and associated software packages.	Remote labs (Item no: 5) Q7: I have virtual labs for my courses where applicable. Q8: I have simulation packages to support my courses. Q9: I have a proportionate student number to conduct remote labs effectively

Table 2: Learner's survey questions using the qualitative approach.

Articles reviewed	Major findings summary	Construct and the statement question used in the survey
[Cole, A.W., et.al, 2019], [Kebritchi, M. , et.al, 2017], [Dray, B.J., et.al, 2011]	Learner's (students) readiness is a large contributing factor in the success of online teaching and learning. 1. Students must have minimum technical skills and resources. 2. identifying and adopting new learning styles suitable for online learning.	Learner's readiness (item no: 1) Q1: I have IT resources to engage in online study. Q2: I have received the necessary training or support at my institution to engage in online study. Q3: Instructors used different learning styles to increase my motivation and analytical thinking.
[Murphy, C.A., Stewart, J.C., 2017], [Jaggars, S.S., Xu, D., 2016], [Bawa, P., 2016].	It is very important to have an effective course content design in online teaching and learning to meet the course learning outcomes.	Effective c ourse content design (Item no: 2) Q4: instructors have designed the course content which is easy to interpret, understand, and apply effectively. Q5: Instructors have used effective assessment methods to validate my learning.
[Song, D , et.al, 2019], [Kim, M.K. and Ketenci, T., 2019], [Correia, A.P. and Jaramillo, N., 2016].	Learner's active participat ion is another contributing factor to the success factor of online learning.	Learner's active participation (item no: 3) Q6: Instructors have provided various online forums for discussion, thinking, talking, observing, and feeling.

2.2 Methodology

2.2.1 Research method:

This research is attempting to investigate the impact of COVID-19 on engineering studies in the sultanate of Oman. A literature review (qualitative approach) is performed to construct the questionnaire survey that helps to understand the academics and learner's perceptions during this rapid remote transition teaching and learning occurred due to pandemic. Academics questionnaire survey consists of five items which hold nine questions. The first item question is framed on technology skills (professional development). The second item questions targets online assessments skills and learning outcome mapping skills through remote learning. The third item question is on time management, the fourth item questions are based on various teaching styles, and the fifth item questions are based on remote lab facilities. On the other hand, the learner's questionnaire survey consists of three items that hold six questions. The first item questions are constructed to understand the learner's readiness in terms of resources and IT skills. The second item questions are on effective course content design for the easy and enhanced learning experience. The third item question is constructed on active participation. All item questions for both academics and learners are constructed on a five-point Likert scale system. Where rating 1 corresponds to strongly disagree and rating 5 corresponds to strongly

agree. Before the dissemination of the survey questionnaire, it is thoroughly checked by various expert questionnaire researchers in terms of wording, content, and appropriateness to the current pandemic outbreak as perceived by the researchers. All the questions are constructed on google forms and are distributed by emails links to all the engineering colleges and universities in Oman.

2.2.2. Data collection and analysis methodology:

The respondent's data is imported into SPSS software. The first step is filtering the raw data, identifying the outlier, and coding into a specific number format to be able to perform the correlation analysis. For instance, if any one of the respondents has not answered any item questions they are treated are outliers in our analysis and have omitted from the further process. Pearson's correlation analysis is the method adopted in our study rather than the traditional descriptive analysis. It helps to identify the gaps and difficulties faced both by the academics and learners at different levels. For example, junior faculty members might be more sensitive towards the understanding and application of the latest technological skills than the senior faculty members. Pearson coefficient "r" value helps to determine the relationship strength and direction between two variables (bivariate). For example, faculties based on academic rank categorized into different number datasets are treated as variable V1 and their recorded responses for a particular survey question as variable V2. Then performing a Pearson correlation analysis using these two datasets helps to understand the agreement strength and direction towards the asked question based on academic rank, experience, etc. Before performing Pearson correlation analysis, Pearson's hypothesis "r" testing is conducted to identify the limit of "r" values for the collected data and also see whether the correlation exists and is valid. The null hypothesis is defined as as H_0;P=0, and Alternative hypothesis is defined as H_a;P≠0, where 'P' stands for sample population considered of the actual population. Because considering the actual population is almost practically impossible and thus not obtainable. Alpha in our study is 0.001 and degrees of freedom (df) is 523 (df = N-2) (where N stands for the sample size of the population) for Academics and 1458 for learners. The decision rule for the "r" value is determined by the Pearson's r standard table [pearson's "r" value, Illinois education resources, 2021]. From the standard table, one can observe that for df values ≥ 100 and Alpha = 0.001 the r-value should lie between -0.254 to +0.254. therefore, if the analyzed Pearson r-values lie in the above range then the null hypothesis is rejected which means the strength and relationship of the obtained results are valid and acceptable. The algorithm for estimating the r-values in SPSS is shown in the figure. 1, The analysis is carried out in four steps. Step 1 is to filter the raw data, assign the coded values as per the below-set table 3.

Table 3: Coding of the filtered raw data into SPSS based on Academic rank, experience, and study level for learners.

Academic rank	Coded data value into SPSS	Experience in years	Coded data value into SPSS	Learner's perception based on the study level	Coded data value into SPSS
Lecturer	1	2-5	1	1st year	1
Assistant professor	2	5-10	2	2nd year	2
Associate professor	3	10-15	3	3rd year	3
Professor	4	15-20	4	Final year	4
		-	5	Postgraduate	5

Step 2 is to perform the Pearson's tests for different surveyed questions to understand the academic and learner's perceptions. Step 3 is to validate the obtained r-values and finally step 4 is to understand the strength and direction of the relationship between the two considered bivariate variables.

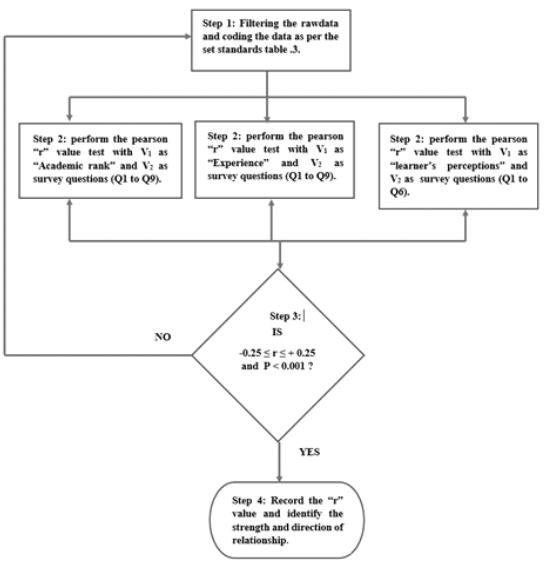


Fig. 1: Pearson's correlation algorithm adopted in our study.

3. Participants and results:

3.1 Demographic information of the participants:

Sultanate of Oman, a member of the Gulf Cooperation Council (GCC) countries hosts a total population of around 4.7 million among which 2 million people are expatriates [ncsi.gov.om, 2020]. Expatriates have remained a major source and choice of labor workforce in building the national economy. On the other hand, high wages, low or no taxation, and a high standard of living are the major reasons for the expatriates to pursue a career in the GCC countries. However, considering the growing population of Oman every year and the demand to meet the citizen's basic needs is also growing continuously. As a result, new governance rules, policies are being introduced into the employment system favoring the local nationals as the main priority in employment both in the public and private sectors. Therefore, various jobs are being replaced with the local nationals. On the other hand, the associated job skill sets required to perform both technical and non-technical jobs are observed to be lacking in the local nationals. These lead to the vision and establishment of a strong educational system in Oman to facilitate the local nationals and empowerment of the society. Currently, the Sultanate of Oman hosts sixty higher educational institutions among which thirty-one are public higher educational institutions (1 university, 29 colleges, and 1 institute) and twenty-nine private higher educational institutions (8 universities and 21 colleges) [Al'Abri, K., 2019,]. All these educational universities, technical institutions, and colleges provide various degrees in the field of science, engineering, technology, and administrative skills to empower the local nationals. The current total number of enrolled students in the country into various degrees (both undergraduate and postgraduate studies) is around 0.2 million. The teaching methodology in most of these institutions is the Outcome-based instructor/lecturer-centered method. The learners are highly dependent on the teacher in terms of subject matters. To contain the COVID-19 pandemic, the ministry of higher education and other associated ministries in the education sector has suspended all face-to-face studies until further notice. Such a sudden decision has left both the students and the academic staff in a state of uncertainty whether to suspend the studies for a while and reschedule the academic calendar accordingly. or adopt the E-learning completely for some of the courses. However, due to uncertainty (exact time) in return to the normal state, E-learning is seen to be a viable solution to continue engaging the students in their studies.

There are thirty colleges in the sultanate of Oman providing various engineering courses in the different engineering disciplines. Among the thirty colleges, 12 colleges are run by the public institution authorities and only one college is from the only public university available in Oman. The percentage of the adopted teaching approaches taught in these public universities and the technical colleges are shown in below table 4. Similarly, there are seventeen colleges from the private domain, among which eight colleges are from the universities and the rest are from the individual colleges. Overall, the majority (around 96.5%) teaching method that is adopted in these universities and colleges is an Outcome-based instructor-centric approach. Authors highly anticipate that the dependence on the instructor-centric approach can be reduced to 75% of the total engineering courses and increase the student-centric learning approach to 25%. As some of the courses in most of the engineering disciplines are constructed to teach some fundamental laws and principles whose value remains constant. For instance, electrical circuit laws such as Kirchoff current law, Kirchoff Voltage, Ohms law are standard rules that are taught to students to understand the analysis and behavior of the circuit. According to the data available from the ministry of higher education in Oman [moheri.gov.om, 2021], there are about 46000 students enrolled in various engineering programs. Figure .2 shows the total distribution of the student enrolled in various study programs. Authors anticipate that the increase in the student-centric approach for some of the courses in various engineering programs can benefit instructors, students, and administration. The instructor here can develop online resources that can be in the form of video lectures, Assignments, daily or weekly activities where students can follow the teaching material virtually and discuss the ideas, problem-solving methods using various social platforms such as Microsoft teams, zoom, etc. For instance, a study [Chen, C.H. and Tsai, C.C., 2021] conducted in Taiwan have presented the high opportunities of using enhanced mobile technology learning to facilitate and design better student-centered learning activities. On the other hand, administrators always enjoy listening to positive feedback from the students in terms of their learning experience, satisfaction, flexibility and overall improving the quality of studies.

Table 4: percentage of teaching approaches adopted in Oman

Public Sector Engineering colleges in Oman	Number (no.)	Outcome-based instructor-centric approach	Student centric-approach
University	1	96%	4%
Technical and Applied science colleges	12	95%	5%
Private Sector Engineering Colleges in Oman			
Universities	8	98%	2%
Technical colleges	9	97%	3%
Total & Average	30	96.5% (Average)	3.5%(Average)

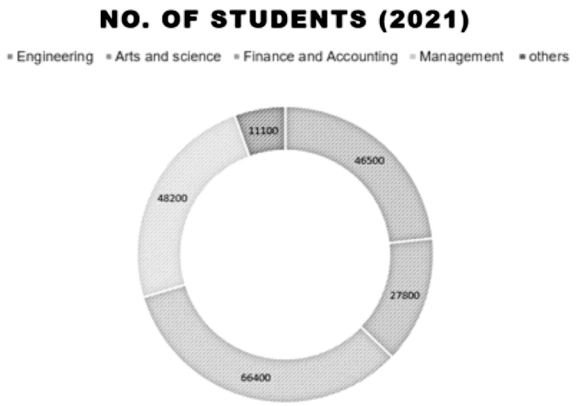


Fig. 2:Total no. of students enrolled in various study programs.

The data collected and analyzed (academics perspective) in this research study have been summarized in table 4. These participants belong to 12 higher educational institutions in oman (6 universities and 6 technical colleges) who are involved in teaching various courses related to various engineering disciplines.

Table 4: Information of the Academics participants in the survey

	Lecturer	Assistant professor	Associate Professor	Professor	Total (percentage)	Mean ± SD
Samples (n=525)	240 (45.7%)	160 (30.4%)	96 (18.2%)	29 (5.5%)	**525 (100%)**	---
By Major						
Civil	58	48	24	8	138 (26.2%)	
Electrical	52	36	26	5	119 (22.6%)	
Mechanical	42	21	14	4	81 (15.4%)	
Instrumentation	34	15	13	2	64 (12.1%)	
Electronics and communication	25	10	8	2	45 (8.5%)	
Aeronautical	11	9	4	3	27 (5.1%)	
others	18	21	7	5	51 (9.7%)	
Total					**525 (100%)**	
Experience (in years)	3-15	2-10	10-18	≥ 20		10.24±4.21
Ethnicity						
Indian	150	55	26	5	236(44.9%)	---
GCC & middle east nationals	75	68	58	11	212(40.3%)	---
European, Canada & American nationals	15	37	12	13	77 (14.6%)	---
Total					**525 (100%)**	

Table 5. Shows the learner's participation samples based on the year of the study in various engineering courses.

Table 5: Information of the learner's (student) participants in the survey

	1st year	2nd year	3rd year	Final year	Masters (MSc)	**Total (percentage)**
Samples (n= 1460)	380 (26.02%)	520 (35.61%)	365 (25%)	145 (9.9%)	50 (3.42%)	1460 (100%)
By major						
Civil	115	121	94	39	18	387 (26.5%)
Electrical	82	211	105	26	14	438 (30%)
Mechanical	50	88	25	21	8	192 (13.1%)
Instrumentation	35	40	66	16	4	161 (11.6%)
Electronics and communication	26	25	35	19	6	111(7.6%)
Aeronautical	22	15	30	8	--	75(5.1%)
others	50	20	10	16	--	96(6.5%)
SEX						
Male	196	412	255	98	42	1003(68.6%)
Female	184	108	110	47	8	457 (31.3%)

3.2 Results:

A quantitative analysis strand is used to analyze the responses received from both the participant groups. The items represented in Tables 1 and 2 are measured on a five-point anchored numeric scale, where 1 = 'strongly disagree' and 5 = "Strongly agree". In addition to that, a thematic comment section was also made available in the survey. However, it is restricted to the three numeric scales 1 (strongly disagree), 3 (neither agree nor disagree), and 5 (strongly agree) to know the reasons and also to gain deeper insight into the participant's reasoning behind their logical choices. Further, the academic participants based on their academic rank are anchored to a numerical scale where 1 = "lecturer" and 4 = "professor" to enable to perform correlation analysis, similarly, based on experience in academics, a five-point numerical scale is developed where 1 = "experience between 2-5 years", 5 = "experience more than 20 years" to gain a deeper insight of the academic perceptions towards the quick transition from FtF to online delivery of their courses. Another advantage would be in correlating their experience with the different constructs of the survey. SPSS 23.0 software is used to perform the correlation analysis. Pearson correlation coefficient is determined for each item in the survey and is presented in Table 6. On the other hand, learners based on their year of study have mapped to a five-point numerical scale where 1 = "1st-year student in bachelor program" and 5 = "Master student in MSc program" to enable to perform the correlation analysis. The student perceptions during the quick transition from face-to-face (FtF) to complete online learning is presented in table 7.

Table 6: Pearson correlation coefficient (r) values to identify the academic perceptions due to the quick transition from FtF teaching mode to complete online mode.

Construct	(item no: 1)	(item no:2)		(Item no: 3)	(Item no: 4)		(item no:5)			Mean ± SD
Questions	1	2	3	4	5	6	7	8	9	
Academic rank (r)	-0.76	0.27*	0.29*	0.53*	0.45*	0.47*	0.31*	0.74*	0.45*	3.01±0.96
Experience (r)	-0.56	0.57*	0.53*	0.33*	0.26*	0.29*	0.26*	0.75*	0.65*	2.96±0.98

Note: *p <0.001; and 95% of the Confidence interval (CI) has remained between the values 0.16 to 0.89 for all the items analyzed in the survey.

Table 7: Pearson correlation coefficient (r) values to identify the learner's (student) perceptions due to the quick transition from FtF teaching mode to complete online mode.

Construct	(item no: 1)			(Item no: 2)		(item no:3)	Mean ± SD
Questions	1	2	3	4	5	6	
Learner's perceptions (r)	0.26*	0.28*	0.56*	0.52*	0.39*	0.62*	2.67±0.95

Note: *p <0.001; and 95% of the Confidence interval (CI) has remained between the values 0.14 to 0.90 for all the items analyzed in the survey. *p

4. Discussions and Recommendations:

4.1 Academic perceptions:

The Pearson correlation coefficient (r) values range from -1 tp +1, where -1 indicates a strong negative correlation ship and +1 indicates a strong positive correlation ship between the chosen variables. Further either it is a positive or negative correlation based on the range of r values they are subdivided into three categories. The Pearson coefficient values (r) present between 1 -0.7 are considered as strong positive correlation, 0.7-0.5 are considered as moderate, 0.5-0.3 fall under the weak category, and less than 0.3 falls under the very weak category [Moore, D.S., et.al, 2015]. A similar approach is followed in the negative Pearson correlation coefficient values (r). In this study, All the item numbers in the academic perceptions have indicated a weak, moderate, and strong positive correlation except item no 1. Where Surprisingly strong negative correlation perceptions are seen to the academic rank and a moderate negative correlation ship is observed concerning the experience. The lower academic ranks such as lecturers have shown more confidence in their technical skills in contrast to the higher academic ranks. Upon analyzing the qualitative thematic responses of the higher academic ranks it has been observed that the rapid transition from an FtF to complete online has been stressful for them due to the limited time and availability of the on-campus support personals. A recent study [Hodges, C., et.al, 2020] has comprehensively discussed the difference between emergency remote teaching (ERT) and online learning. Both are different aspects and cannot be compared with each other. However, the possible requirement for ERT should become a part of the faculty member's skill set, and also in their professional development program and also in the risk register of the academic institutions.

The r-values of construct 2 (Awareness in assessment methods and mapping of learning outcomes) concerning academic rank is a very weak positive correlation. This indicates most of the junior and few mid-career faculty members are facing a lack of

knowledge in adopting various assessment methods suitable for online teaching and learning. Engineering courses have a wide variety of learning outcomes to achieve in terms of design aspects, understanding and remembering, applying, evaluating, and innovation. Using the Same traditional assessment methods during the face to face learning is not effective in online learning. For instance, conducting an assignment that involves developing a new model or design right after posting the content discussed with few examples into the LMS (learning management system) is not an effective way of assessing the students [Kenzig, M.J., 2015]. Regular instructor active interaction (online forum discussions, online conferences, etc) with the students must be there to allow the students to practice on the development of the new model or design in pieces along with the instructor's feedback. On the other hand, the r-value concerning experience-based has shown a moderate positive correlation. Although a few faculty members despite having high academic experience in years are still under the first stage of the academic ranking tree(lecturers) due to the qualification limitations. However, they have demonstrated high confidence in knowing the suitable assessment methods adopted online as a result showing a moderate positive co-relationship with construct 2.

The r-values of Construct 3 (time management) concerning academic rank is a moderate positive correlation. The academic professionals having ranks Associate professor and full professor have shown positiveness in terms of availability of time to transit while the academic professionals with ranks Assistant professor and lecturers have shown lower positiveness. Analyzing the thematic responses of the survey participants has led us to conclude that this is mainly due to the higher teaching workloads for the ranks lecturer and assistant professor. [McCaslin, S. and Brown, F., 2015] study reports citing various references that the time required to teach a regular FtF course into a completely online format is almost double. Therefore academic professionals having a higher teaching load is a strong matter of concern that needs to be considered especially during emergency risk circumstances. Since some of the major advantages considered in FtF learning are better faculty interaction, student engagement, and collaborative learning [Paulsen, J. and McCormick, A.C., 2020]. Achieving the same advantages in online learning mode will remain as a challenge if the instructors are facing time management challenges.

The r-values of Construct 4 (teaching styles) concerning both academic rank and experience is a weak positive correlation. The thematic analysis of the survey participants has shown that this is due to the lack of professional development activities and the advanced infrastructure related to this area. Effective teaching styles play a very crucial role in the successful teaching and learning of online courses. Some effective strategies include dynamic presentations, lab tutorials, simulations, virtual labs, conceptual discussions, active interaction, and collaboration with the learners to support their knowledge developments and activities [Torrent, M., 2020], [Lager, I.E., et.al, 2020].

The r-values of construct 5 (remote labs and associated software packages) concerning both academic rank and experience are further categorized into three sub-categories 1) the presence of virtual labs 2) usage of simulation tools and 3) proportionate student number. The r-values for virtual labs concerning both academic ranks and experience fall under the weak to very weak category. Thematic analysis of the survey respondents has shown that no significant move has been taken towards establishing the virtual laboratories. [Sarac, V.J., et.al, 2020] study has reported the use of two virtual laboratories in the field of electrical circuits and electrical machines. This research study has demonstrated that students can achieve the same set of experimental skills as physical laboratories with easy access anywhere and anytime. They also reported that virtual laboratories are cost-efficient for those who are facing financial hindrances. However, lack of real-life delays (measurement errors) and skills to troubleshoot the real faulty equipment are still drawbacks in virtual labs. Questions 8 and 9 are framed based on understanding the reasons laid out by the semi-structured interview of the 6 faculty members belonging to various engineering disciplines. The interview lasted for ten minutes, mainly focusing on the methods adopted by them to conduct the engineering labs. the synchronous approach is observed from all the respondents where remote access has been provided to the institution lab computers, further assistance is provided by the lab technicians to facilitate student questions. However, student numbers have seen a bit of concern, because the labs with higher student numbers have seen a risk of long waiting times for their turn to run the simulation experiment. This is because of variation in the workload levels of the different academic ranks and is also evident from the r-values where a moderate

positive correlation is observed concerning academic rank. However, a strong positive relationship is observed based on experience which is obvious that the high experience is likely to be higher academic ranks thus having lower workloads. On the other hand, the availability of the simulation tools has been observed with a strong positive correlation concerning both academic ranks and experience.

4.2 Learner's perceptions:

The r-values of construct 1 (Learner's readiness) for three questions have shown very weak to weak co-relationships. Thematic analysis of the survey data has resulted in learner's issues in three areas 1) access to the internet and IT devices (laptop) 2) complete knowledge/skills on LMS 3) language barriers. [Swart, A.J., 2015] study has highlighted the significance of having access to the internet, and complete technological skills in LMS, are the factors that contribute to the effective learning of the students. Language barriers also contribute to the process of effective learning as the student's weak English skills may prohibit them to ask more questions in online interaction sessions and thus causing the poor performance of the student. [Crawford-Ferre, H.G., 2012] study noted that language barriers are also another factor in poor performance and engagement during the online mode of study in contrast to the regular support they would receive during normal FtF studies. All students have different backgrounds with a different atmosphere to study from their living places, for instance, some students live in very remote locations where accessing to internet and other IT infrastructure is very challenging for some students, and it may not for other students. Similarly, financial support to afford the internet data packages, IT infrastructure may also be very challenging for some students. When students study on-campus they have equal opportunities towards the infrastructure and other challenges that might be very difficult to achieve when they study from their living places. Therefore, supporting students with extra data packages, and minimum IT infrastructure could be a good strategic plan by the government to provide equal opportunities to all the students irrespective of their backgrounds.

The r-values of construct 2 (Effective content design) have shown moderate to weak relationships. Proper attention is needed during the transition of an FtF course to online teaching. [Koehler, M.J., 2004] study has noted that the same FtF content cannot be copied and used in online mode. Applying course redesign strategies and integrating technology tools enhances online learning. Further, it also helps in the reduction of costs and increases retention rates of the students [Abernathy, Dixie F. et.al, 2020]. The instructors are encouraged to take into consideration the technology, pedagogy, and appropriate content when designing online courses. usage of multimedia tools such as animations, videos, simulations, and design practices are all the contributing factors in enhancing learning in engineering courses [Hoic-Bozic, et.al, 2008]. The r-values of construct 3 (active participation) have shown moderate co-relationship. Nonetheless, few strategies and recommendations (such as active collaboration, student-faculty interaction, rich educational experience, and supportive off-campus environment) have been presented to instructors and high-level administrators to keep up the student engagement [Meyer, K.A., 2014]. Learners must be continuously engaged and made sure that their individual learning experience is made more fun, innovative, and analytically thinkable to the problems they observe around them. Most of the time traditional FtF learning style may not be effective in achieving them, some learners enjoy learning by simulations and experiment (i.e. test and observe) for the practical part and some by animations, video for theoretical form, and also discussion plays a very crucial role in improving the learner's satisfaction. Therefore adopting various evolving ICT technologies where possible and continuously modifying the teaching methods and collecting feedback from the students all contribute to improving the overall learners learning experience, motivation to learn, and most importantly student satisfaction.

4.3 Role of administrators:

A research study [Lemoine, P.A., and Richardson, M.D., 2020] highlights the significance and need for appropriate planning by administrators that have been missing in the traditional higher education institutions to tackle the pandemic risks. It also highlights that traditional higher educational institutions have to offer something more than online education institutions because if students would have just opted for online education, they wouldn't be enrolled in traditional institutions. Another research study [Bokolo Jr, A., et.al, 2020] has proposed a strategy and framework on how to diffuse the blended learning education slowly into the institutions after surveying about 223 administrators working in different higher educational institutions. The faculty and students are

not only the ones to make successful online education and learning. Even, Administrators or high-level managers of the institutions have also a very crucial role in adding success to it. There are some roles where administrators can only satisfy. Such as funding faculty development, maintaining the quality of the online education, deploying and supporting the required infrastructure to deliver the online courses effectively, help the students in their concerns causing the hindrances in their learning whether be it in social, technological, or economics matters. Based on the results obtained in this research study, the role of administrators can play a very positive correlation to handle the difficulties, improving the gaps identified during the remote teaching and learning. The correlation results for each item question rated by the respondents are given in table 8. In the academics section, item no: 5 (virtual labs) has been obtained very weak to weak positive correlation. This means most of the respondents have disagreed with the virtual lab facilities available in their corresponding institutions and thus this item no was given high priority i.e. rank 1 and the respective recommendation which administrators can help in improving this identified gap. Similarly Item no: 3 (Time management) has obtained a moderate positive correlation, which means most of the respondents have agreed that they had enough time to make transition and thus ranked IV. On the other hand, in learner's perceptions item no: 1 (learner's readiness) has observed with very weak correlation and thus ranked 1. This somehow reflects that the support or training needed to understand the technology was missing in their respective institutions. Therefore, training sessions must be conducted at a regular pace for the students to understand the technology systems that are available in their respective institutions.

Table 8: Recommendation to administrators based on the correlation results observed in this study.

Questionnaire construct item no:	Correlation results	Priority Rank	Recommendation mapping below:
Academics			
Item no: 1	Academic rank: strong negative Experience: moderate negative	Rank V	1
Item no: 2	Academic rank: weak positive Experience: moderate positive	Rank III	4
Item no: 3	Academic rank: moderate positive Experience: moderate positive	Rank IV	5
Item no: 4	Academic rank: weak positive Experience: weak positive	Rank II	6
Item no: 5	Academic rank: very weak to weak positive Experience: very weak to weak positive	Rank I	2
Learner's			
Item no: 1	Learner's perceptions: very weak to weak positive	Rank I	3
Item no: 2	Learner's perceptions: weak to moderate positive	Rank II	6
Item no: 3	Learner's perceptions: moderate positive	Rank III	2

4.4 Recommendations:

1) Effective online teaching skills, Assessment methods, teaching styles, content creation, and mapping learning outcomes. Faculty members sometimes get dependent on the support of the administrators to acquire them. For instance, providing subscription access to high-quality journals and magazines where the latest and best practices are documented. Conducting workshops on-campus by inviting experts or encouraging faculty to attend such workshops where they occur. These all should be part of the faculty annual CPD's (Continuous Professional Development) program.

2) Building and maintaining necessary Infrastructure, provide training of technical skills for both faculty and students. Successful online education and learning need a supportive technical infrastructure in place. This includes a learning management system (LMS), IT infrastructure, virtual labs, content or media creation tools, etc. on the other hand, technical skills in using these resources effectively also play a major role in the success of online teaching and learning.

3) Establishing a Student Support Center. Effective student engagement is another KPI (Key performance indicator) to measure the quality and success of online education and learning. Generally, students face various issues where faculty may not be able to address all of them, such as economic issues, social problems, technological and language barriers, etc. Having dedicated personals in the support center to address the

student grievances or appointing the volunteers or generally termed as peers per course are all good practices to enhance online teaching and learning.

4) Funding research in online education and the environment. Administrators should consider funding research projects (even if small budget) in the area of online education and learning. Generally, faculty provide merits to research and also learn from it. It is not just faculty, even other audiences such as various administrative departments in the institutions, and even students can benefit from the findings of the research conducted and thus might be helpful in overall improvements in the quality.

5) Effective workload allocation and time management. Both principles play a very crucial role in maintaining and improving online teaching and learning quality. It is evident from many online instructors that the amount of time required to construct, teach an online course is higher than the FtF courses. Therefore, effective policies need to be developed, deployed, and improvised regularly to balance the concerns reported by the students and faculty members.

6) rewarding incentives for innovations in online teaching and learning. Recognize and awarding the individuals (either it is for faculty, volunteers, or peers, high performing students) for their exceptional efforts made in the online teaching and learning process. For instance, promotion decisions for the faculty in their annual appraisal. Financial discounts to the high-performance students or even certificates of appreciation for the volunteers will all add a positive encouraging boost in the performance of their respective roles and thus contributing to the effective online teaching and learning process.

4.5 Comparisons and a Way forward

In general, the teaching and learning practices in engineering colleges differs from region to region and institute to institute based on its establishment, funds availability, research performance, and the type of students. For instance, a research study [Dziuban, C., et.al, 2018] conducted in the USA has shown that blended education in various courses has shown better results in overall performance (grades) of the students, student retention rates, and strong desire to take such courses rather than taking courses which are completely following Ftf approach and only online modes. Another interesting study [Wu, T.T. and Wu, Y.T., 2020] showcased how project-based learning has improved creativity and critical thinking in high-creativity learners and low-creativity learners. The current teaching and learning practices in the sultanate of Oman majorly constitute the FtF approach combined with the usage of learning management systems (LMS) technology. However, since the outbreak of the pandemic, it is evident that the existing teaching and learning methods were not sufficient to handle the occurred risk effectively. Lacking continuous innovation in teaching and learning methods, lacking continuous professional development for both faculty and students, and failing to adopt the evolution in the new technologies are seen to be the major problem for the low confidence shown during pandemic risk. A case study [Ożadowicz, A., 2020] presented how modifying the blended education system in engineering higher education has been very effective in tackling the pandemic risk effectively. The authors recommend adopting the blending education system by utilizing the latest information and communication technologies (ICT) for content creation (videos), online discussions platforms, self-learning, virtual lab infrastructure possibilities, assessments (tests and quizzes) where possible to at least some of the courses as a starting point. Regular Innovation and modifying the course teaching and learning methods can help to build a rigid engineering higher educational system that can not only handle the pandemic risk effectively if occur in the future but also helps in improving the overall standards, quality of educational experience as a whole.

5. Conclusions:

This study has used mixed methods to address the challenges faced due to emergency risk (COVID-19) in engineering education. One of the main challenges is the rapid transition to complete online teaching and learning modes from blended/asynchronous online teaching and learning modes. Academics have observed challenges in terms of technological skills, teaching styles, time management, virtual labs infrastructure availability, and Assessments skills. Learners have seen difficulties in access to online resources such as the internet and IT devices, lack of training support in using technological skills effectively, and suitable assessment methods. Further recommendations to the high-level administrators are also discussed to improve online education quality.

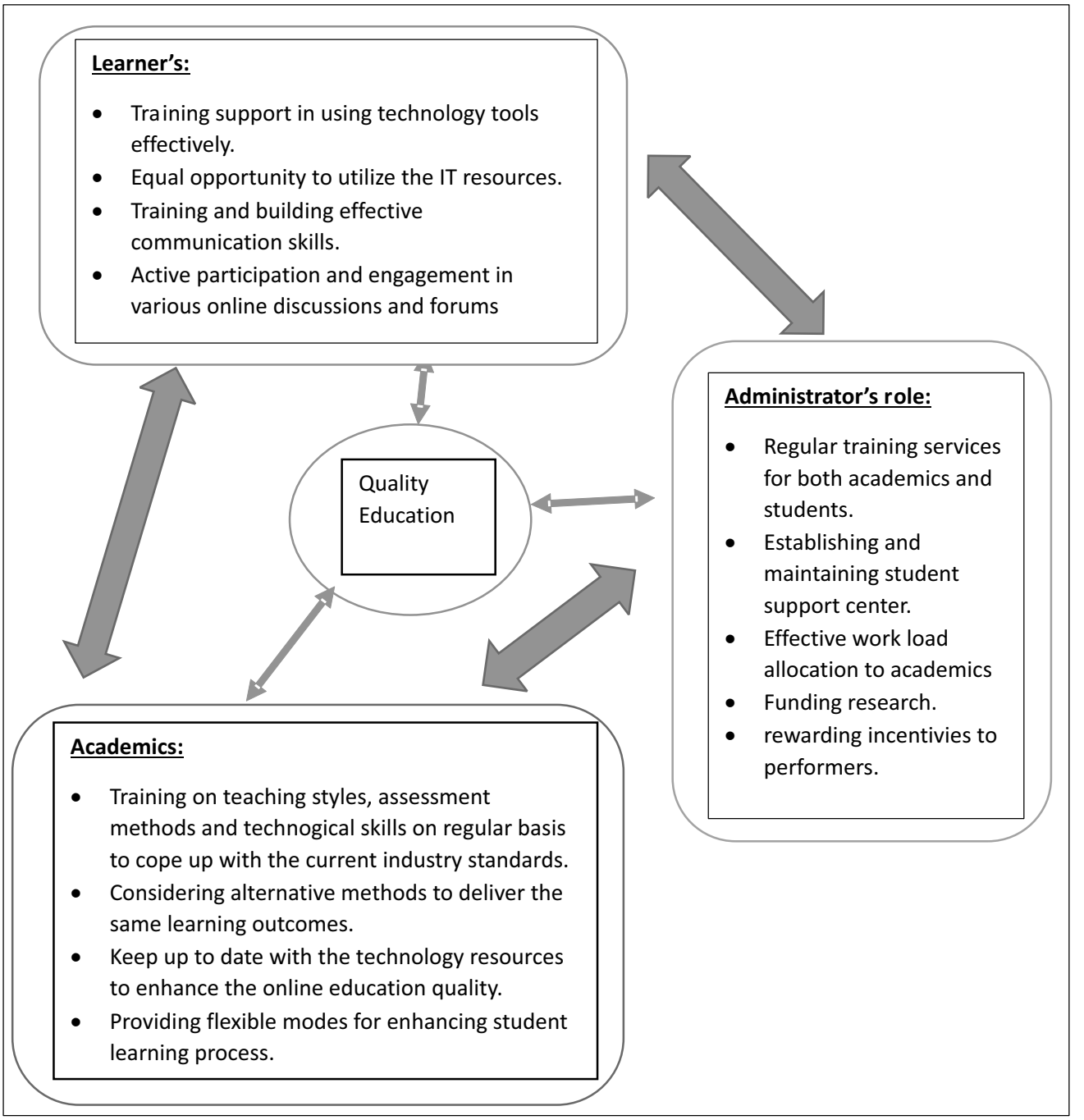


Fig. 3: Factors that need to consider in tackling emergency risks effectively in three major categories and also contribute to achieving quality education

The other important aspect of this research study is also to identify the factors that need to be incorporated into engineering education in regular such that any future emergency risks can be handled in confidence. Those factors are aligned with cooper's framework and are presented in figure 3. Therefore, the recommended factors are hoped to be adopted by the education institutions as a part of CPD for all three major categories and thus become robust to handle any kind of emergency risks if occur in the future and also to improve the overall quality of the education.

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Developing synchronous and asynchronous online learning models for engineering college students in India: A grounded theory approach

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Abstract: The Covid 19 pandemic lockdown in India led the education to move from classroom learning to online learning. This created the need for online learning pedagogies. The current study focuses on developing synchronous and asynchronous models of online learning for engineering students. The data for the current study was collected through interviews of engineering students of different specializations. Transcription of interviews were prepared and subjected to three levels of coding i.e. open coding, axial coding and selective coding in order to prepare concepts. The concepts were then integrated into a model using grounded theory approach. The finding indicate that synchronous mode leads to group learning, peer learning, learning through simulation and effective learning. The asynchronous mode leads to reinforcement based learning.

Key words: online learning, engineering, India, synchronous, asynchronous

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1. Introduction

Covid 19 was declared as a pandemic by World Health Organization in January 2020 (Zheng et al 2020). As a Covid 19 cases in India began to rise, it was decided by the Government of India to announce 21-day nationwide lockdown starting from 25th March 2020 (Ghosh et al., 2020). This led to the shutdown of schools, colleges and universities (Chatterjee 2020). The prolonged lockdown in the country suddenly created a demand for online learning methodologies (Pattnayak & Pattnaik 2020). Online learning is not a new concept in India (Mishra 2009). Over the years' education in India has grown from distance education through e-learning platforms to massive open online courses (Gupta & Jain 2017). As compared to schools and colleges, higher education in India has gained enough importance as they are more focused on developing professional skills of students (Mathews et al 2013).

The Covid 19 pandemic situation led all institutions to re-design their pedagogy for effective digital learning (Crawford et al 2020). The most popular digital pedagogies are synchronous and asynchronous modes of learning (Dahlstrom-Hakki et al 2020). In synchronous learning mode, there is live interaction between the instructor and student through online platform (Chen et al 2005). In the asynchronous mode, it relates to learning at anytime and anywhere through the internet medium (Rovai

2002). Both the methods of learning have their own set of advantages and disadvantages (Chen et al 2005). The online learning pedagogies will only be successful when it meets student expectations (Bourdeaux & Schoenack 2016). Hence the major focus of the study is to develop a student model for synchronous and asynchronous learning. This will help in designing effective learning methodologies.

Learning model can be developed by both qualitative and quantitative approach (Shi et al 2019). Quantitative is an objective approach while qualitative is a subjective approach (Johnson and Christensen 2019). A good research is a combination of both subjective and objective approach in order to strengthen the external validity (Brannen 2017). The current study proposes to apply qualitative approach to developing synchronous and asynchronous model of learning. The qualitative approach would help to develop a contemporary model of learning to better understand the phenomenon (Charmaz, 2008). The qualitative approach will help to identify concepts related to synchronous and asynchronous modes of learning (Holton 1988) which will then be integrated into a theoretical model using grounded theory approach (Glaser & Strauss 1967). This will enable the model to be an effective tool for learning.

2. Research objectives

1. To develop synchronous model of online learning for engineering college students.

2. To develop asynchronous model of online learning for engineering college students.

3. To understand the challenges faced in implementation of synchronous and asynchronous learning models.

3. Literature Review

There have been significant changes in the mode of learning. Over the years, conventional learning has been replaced by online learning platforms (Mayende et al 2016). The most widely used online learning platform is learning through mobile apps (Al-Emran et al 2016). Another mode of learning is blended learning which is a combination of online and conventional mode of learning (Lee et al 2017). Introduction of gamification has further made learning more interesting (Subhash & Cudney 2018). Introduction of massive open online courses (MOOCs) have further enhanced the learning process. The Covid 19 lockdown has made it mandatory to move from traditional classroom learning mode to online learning mode (Fields & Hartnet 2020). This has created a need to make online learning more effective by mapping student expectations.

Previous studies have shown varied expectations from learners. Bourdeaux & Schoenack (2016) concluded that poor usage pedagogical tools resulted in negative learning outcomes. Ragusa (2017) was of the opinion that technology tools should meet learner expectations. Jung & Lee (2018) emphasized on the need of academic self-efficacy for better learning engagement. A study by Parahoo et al (2016) found that student satisfaction was an important driver for the success of online learning. Students perceive that engagement matters irrespective of the mode of learning (Martin and Bolliger, 2018). De Guzman (2020) researched that the Covid 19 pandemic lockdown has created a demand for synchronous and asynchronous mode of learning amongst the learner community.

Research on synchronous and asynchronous mode of learning has been more than two decades old. It important to understand the different aspects of both the tools individually and in combination. Hampel (2006) explained that synchronous learning is very different from face to face learning. Marjanovic (1999) observed that despite synchronous mode of learning, students prefer to learn through personal interaction. The author suggested that an online environment should be made as interactive as physical learning to facilitate effective learning. According to Chen et al (2005), sufficient internet bandwidth is important to make online teaching through the synchronous mode effective. Passonneau and Coffey (2011) propagated synchronous virtual classroom with the use of grounded theory approach. Recent research has found that blended synchronous learning is the most effective learning medium (Szeto & Cheng 2016). However, learning can be effective only when certain online protocols are followed to make the online discussion move in a structured manner (Zydney et al 2020). The challenges of synchronous learning have given scope for the growth of asynchronous learning.

Historical learning has shown that asynchronous learning is extensively used in distance learning since there is a flexibility in learning (Moller 1998). Hammond (2005) found that curriculum structure,

technology, instructor support and attitude of learners is important for the success of asynchronous learning. Mnih et al (2016) observed that asynchronous learning is a good method for reinforcement of learning since the content can be seen multiples times. Costley (2016) was of the view that greater the instructor control during asynchronous learning was important to make the learning more effective. However, instructors find it difficult to interpret the outcomes of asynchronous learning (Giacumo & Savenye 2020).

A comparison of synchronous and asynchronous learning has also been done by many researchers. Lim (2017) identified the difference in communication tools with respect to synchronous and asynchronous learning. The author emphasized the role of web conferencing, live chat and white boarding in synchronous learning while discussion forums, email and social media messaging in asynchronous learning. Hence, technology is a common driving factor to both the modes of learning. Chadha (2018) stressed on the need of collaborative learning which is a combination of synchronous and asynchronous approach to make learning more engaging. A study by Rosenberg et al (2017) indicates the difference in learner sentiments in synchronous and asynchronous learning through twitter messages. Nieuwoudt (2020) was of the view that class attendance and participation is important to get good scores in both methods of learning. A review of the existing literature has shown many commonalities in both synchronous and asynchronous learning.

India has adopted the synchronous and asynchronous mode of learning since a decade (Rao 2011). The adoption has happened from primary education right up to higher education (Jena 2019; Buttar 2016). Distance learning in India has adopted synchronous and asynchronous learning in a big way (Buttar 2016). Learners prefer a mix of both the learning modes to reduce the monotony in learning (Dey & Bandyopadhyay 2019). The Covid 19 lockdown has made it mandatory to move from a conventional learning mode to the digital mode (Chatterjee 2020). Hence a thorough research to better understand student expectations from both the modes of learning is important.

4. Research Methodology

Research Design: Qualitative approach will be used to address the research question.

Qualitative approach: Initially interview questions were prepared and tested on a small sample of respondents as well as verified from educational experts for their appropriateness. Based on the validated questions, responses were gathered from students of engineering colleges with respect to synchronous and asynchronous mode of learning through written transcriptions and structured interviews as per the comfort level of the respondents. The interviews were then transcribed for further analysis using grounded theory approach.

Grounded theory is a qualitative research methodology which focuses on development of theory from concepts grounded in the data (Glaser and Strauss, 1967). Unlike in quantitative methodology where the objective is to define a theoretical model and test it with data, in grounded theory, theoretical models are developed from available data in order to make them more contemporary (Corbin & Strauss, 1990; Charmaz, 2020). The data is collected in the form of interviews of participants using the method of theoretical sampling (Charmaz, 2020). Initially, first interview is taken and the data analysis starts immediately by transcribing the interview and analysing them to derive key insights of concepts. A set of probing questions are asked in the interview. Then the next interview is conducted and a similar process is repeated to get new insights. The process continues and stops at a participant when there are repetitions and no new insight is forthcoming. This is the point of theoretical saturation and the sampling method is called theoretical sampling.

The insights gathered during data analysis are then subjected to three levels of coding:

1. Open coding: In this process, the insights were derived from interviews.

2. Axial coding: The insights which were similar in nature were clubbed to create concepts.

3. Selective coding: The concepts created during axial coding which are similar in nature are clubbed under a common core concept. The relationships between the concepts were identified to create a theoretical model.

The responses for the current study were gathered from the city of Pune which has been designated as one of the education hubs of India for engineering education. The data was collected through a

purposeful sampling method (Charmaz, 2008). The respondents were selected and interviewed based on the objective and context of the study. The data analysis progressed simultaneously. Based on the outcome of analysis, more respondents were interviewed. The data analysis continued till no new findings emerged and saturation was achieved. This is called as the point of theoretical saturation (Corbin & Strauss, 1990). Hence, theoretical saturation occurred at a sample size of 44 respondents. The sample size in qualitative research depends on scope and nature of the study and large sample size may not give focused results (Charmaz, 2020). The respondents were from different engineering colleges. 40 % of the respondents were from first and second year while 60 % were from third and final year. 54.5 % were females while 45.5 % were males. The respondents were asked questions relating to their expectations and experience in online learning (Refer Appendix)

The qualitative-raw-datasheet was prepared and was content analyzed which helped to create concepts related to synchronous and asynchronous learning. The concepts were then related to each other and integrated into a model by identifying the relations between the concepts (Glaser & Strauss, 1967).

5. Results

Table 1: Process of coding

Respondent no	*Open Coding*	*Axial coding*	*Selective coding*
R1	Online learning through zoom gives better class interaction	class interaction	synchronous methodology
R2	Case studies can be discussed and on the sport doubts can be cleared	class discussion	synchronous methodology
R3	We can learn in our free time through videos	time flexibility	asynchronous methodology
R4	Live assessments are possible	live assessments	synchronous methodology
R5	If I miss a class due to connectivity, I can see the class recording and learn	class recordings	asynchronous methodology
R6	Learning is also dependent on IT the platform used	Technology platform	synchronous methodology
R7	In asynchronous, learning becomes boring as there is no class interaction	individual learning	asynchronous methodology
R8	On the spot evaluation such as viva is possible in synchronous mode	prompt evaluation	synchronous evaluation
R9	Teacher needs to be equally motivated for effective learning in synchronous mode.	teacher motivation	synchronous methodology
R10	Learning engagement is better when teacher and student are face to face in online mode.	class engagement	synchronous methodology
R11	In asynchronous, if the video quality is poor, learning is ineffective	video quality	asynchronous methodology
R12	Peer learning and class participation is better in synchronous learning	peer learning	synchronous outcome
R13	Assignments are within the videos in asynchronous mode of learning and video does not get completed unless assignments are completed	inbuilt assignments	asynchronous evaluation
R14	In online class we can connect from anywhere	flexible location	synchronous methodology
R15	If the teacher is good, learning is fun in synchronous mode	teacher quality	synchronous methodology
R16	If the sessions are recorded, you can see them again and again	reinforced learning	asynchronous outcome
R17	In synchronous learning, we can organize group activity	group learning	synchronous outcome

R18	After classroom lectures, we are sent additional videos and there are assignments based on them	blended learning	synchronous and asynchronous outcome
R19	Practicals happen through simulation so we are able to get paracical exposure	simulation based learning	synchronous outcome
R20	Using tools like chats, videos and discussion to make the class more interesting	variey of learning tools	synchronous methodology
R21	Online learning impacts psychological health	psychological health issues	synchronous challenges
R22	Asynchronous mode in the form of articles, videos from different sourcesenriches your knowledge	learning enrichment	asynchronous outcome
R23	Sitting online for long hours is not possible so there should be breaks in between the class	low attention span	synchronous challenges
R24	Synchronous learning provides better experience	experientia l learning	synchronous learning outcome
R25	Evaluations can happen through presentations and viva	presentatio n and viva	synchronous evaluation
R26	The class control is difficult in online mode as teacher does not know what the student is doing.	class control	synchronous challenges
R27	Classes can be held during anytime	time convenien ce	synchronous methodology
R28	Internet speed has to be good to conduct the class successfully and while watching videos	good internet speed	synchronous challenges
R29	Student participation and involvement is the key to success	student involveme nt	technology challenges
R30	There should be some norms so that students remain mute when one is speaking and there is no chaos	online etiquetes	synchronous challenges
R31	Online evaluation provides instant results	instant results	synchronous and asynchronous evaluation
R32	Students are not able to express themselves	expression barriers	synchronous challenges
R33	Faculty should ensure that class should not be monotonous by bringing in variation	variation in teaching	synchronous methodology
R34	If a student misses an online class, he can see the recordings	alernate learning modes	synchronous methodology
R35	Asynchronous videos can be seen in free time	time convenien ce	asynchronous methodology
R36	In online teaching,there are issues of content privacy	content privacy	asynchronous challenges
R37	More engagement softwares should be used in online learning to make learning effective	engageme nt softwares	synchronous methodology
R38	The students can see live videos on different equipments which will give practical exposure.	live demonstrat ions	asynchronous methodology
R39	Artificial intelligence can make learning more effective	effective learning	synchronous outcome
R40	Faculty and students need to be trained to operate online technology	training	synchronous challenges

R41	We expect special sessions on doubt clearing as in the online mode since there is no direct interactions	teaching clarity	synchronous methodology
R42	Technology is the biggest driver of online classes	robust technology	technology challenges
R43	Technology should provide diferent features for smooth learning	technology updation	technology challenges
R44	Technology should be compatible with number of devices	technology compatible	technology challenges

Inferemce

The interview transcriptions were broken into small pieces of information from which insights were derived and given conceptual labels. Similar concepts were then clubbed under core concepts. The core concepts that were identified were synchronous and asynchronous – methodologies, evaluation, learning outcomes, implementation challenges and technology challenges. The core concepts were further presented in tabular form which highlighted the responses of individual participants.

Table 2: Synchronous methodology

Concepts	*Respondent no*
class interaction	R1
class discussion	R2
teacher motivation	R9
class engagement	R10
flexible location	R14
teacher quality	R15
variey of learning tools	R20
time convenience	R27
variation in teaching	R33
alernate learning modes	R34
engagement softwares	R37
teaching clarity	R41

Inference and Discussion

The participants indicated that the synchronous mode of learning could incorporate number of methodological tools in order to make learning more effective. These relate to the following

1. class participation such as class interaction, class discussion and class engagement including engagement software.

2. teaching aspects such as teacher quality, teacher motivation, teaching clarity and variation in teaching.

3. learning aspects such as variety of learning tools and alternate learning modes

4. Student convenience such as time convenience of student and flexibility in student location so that the student can join the class from anywhere.

In order to make the synchronous methodology more effective, the right mix of pedagogy needs to adopted. Taking examples from Harvand and Stanford, the faculty conduct case studies which helps in class participation. The teacher ascts as a facilitator to motivate students to participate. The class time is flexible and including variety of learning tools such as gamification and simulation leads to effective learning.

Inference and Discussion

The synchronous mode of learning facilitates prompt evaluation by conducting online presentations and vivas. There can be live assessments in the form of online quiz, simulations and gamification. The synchronous mode provides prompt results of evaluation. The distant mode of education in India through synchronous mode became very popular because it facilitated quick evaluation.

Table 3: Synchronous Evaluation

Concepts	*Respondent no*
prompt evaluation	R8
presentation and viva	R25
live assessments	R4

Inference and Discussion

The most important element in any teaching – learning activity is the learning outcome. The synchronous mode of learning facilitates different types of learning outcomes. The group learning could happen by giving group tasks through students where they could go the break out rooms and perform the tasks. They could also make group presentations. Peer learning could happen as a result of class discussion where students could be encouraged to participate. The technical and managerial skills could be leaarnt through simulations. Simulation softwares backed with artificial intelligence algorithms also provide experiential learning since the practical tasks are performed in a simulated environment and this makes learning very effective. All the reputed institutions in India and abroad evaluate students on the different learning outcomes.

Table 5: Synchronous mode challenges

Concepts	*Respondent no*
psychological health issues	R21
low attention span	R23
class control	R26
student involvement	R29
online etiquetes	R30
expression barriers	R32
content privacy	R36
training	R40

Inference and Discussion

Since synchronous mode is based on online classroom teaching, it affects the psychological health of both teachers and students if sessions are continued from prolonged periods. Since there is no physcal interaction, the students have a low attention span and they may remain logged in without any involvement. Since the students are not physically present, it is difficult to exercise control over them and all the students may speak at the came time thereby creating a chaos. Hence the students need to be given an orientation on online etiquetes. The students are behind the cameras an face a problem of expressing themselves. Students may openly share confidential content outside the institutions thereby creating privacy, Hence there needs to be thorough training on usage of online resources.

Table 6: Asynchronous methodology

Concepts	*Respondent no*
time flexibility	R3
class recordings	R5
individual learning	R7
video quality	R11
time convenience	R35
live demonstrations	R38

Inference and Discussion

The asynchronous methodology is different from synchronous methodology since it is not dependent on time bound schedule. In asynchronous mode, students can watch class video recordings and other related videos (MOOCs) on different online platforms in their free time and as per their convenience leading to individual learning. They can also see recordings of live demonstrations. However, if the video quality is not good, it will affect the process of learning. Hence teachers should give emphasis on the quality of video being recorded. The Ministry of HRD, Government of India is encouraging the usage of MOOCs for effective asynchronous mode of learning.

Table 7: Asynchronous Evaluation

Concepts	*Respondent no*
inbuilt assignments	R13

Inference and Discussion

For effective evaluation, the asynchronous videos can have inbuilt assignments where the students will have to complete the assignment else the video will not be completed. The premier institutions of the country have already adopted this mode of evaluation.

Table 8: Asynchronous learning outcome

Concepts	*Respondent no*
reinforced learning	R16
learning enrichment	R22

Inference and Discussion

The outcome of asynchronous mode of learning is that learning is reinforced by watching the subject videos again and again. This helps to retain the knowledge in the mind of the student. In addition to

classroom session, if students watch additional videos of latest happenings in their specialization area, their learning will get enriched. The academic institutions encourage students to keep themselves updated on the latest happenings in their area of specialization.

Table 9: Asynchronous mode challenges

Concepts	*Respondent no*
content privacy	R36

Inference and Discussion

The major challenge in asynchronous learning is that the students may violate the privacy policy of the institution by sharing academic videos on public platforms. They may also share recordings of class sessions on the public platforms like YouTube. Hence, the engineering colleges should take an undertaking from the student with respect to privacy policy.

Table 10: Technology challenges

Concepts	*Respondent no*
good internet speed	R29
robust technology	R42
technology updation	R43
technology compatibility	R44
technology platform	R6

Inference and Discussion

Technology is a major driver for both synchronous and asynchronous mode of learning, hence the technology must be robust. Since learning happens through technology platform such as Zoom, Googlemeet or MS Teams, it requires good internet speed. The learning platforms should be compatible with all electronic devices like mobile, laptop and desktop so that the students can learn through any device based on their affordability. Students and faculty should use the latest updated version of technology which has got the latest features for effective learning.

6. Model development

Based on the interrelationships between the concepts, models of synchronous and asynchronous learning were developed. The learning models include methodology, evaluation, learning outcomes, challenges in implementation of models and technological challenges.

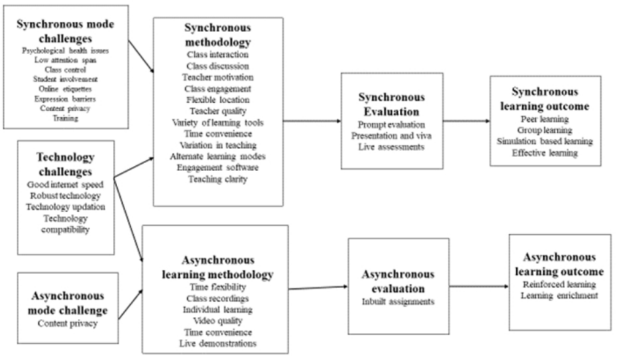


Fig. 1: Synchronous and Asynchronous learning model

Working of the proposed models

(i) Synchronous model

The important elements of the synchronous learning model are methodology, evaluation, learning outcome and challenges.

Methodology

Methodology relates to the teaching pedagogy to make the learning effective. The teacher can discuss topics related to design and development that encourage class interactions and class discussion. The class becomes more interesting when there are quality teachers in terms of their knowledge and they bring out variation in teaching using real life examples, case studies, simulations, videos, group tasks which lead to greater class engagement. The teacher should be able to motivate the students in the learning process by explaining the practical implications of the topics in real life situations. The advantage of synchronous learning model is that students can join the class from any location and the classes can be scheduled at any time of the day since students do not have to physically travel. This will help to conduct guest sessions beyond regular teaching hours of the students. The teacher can use variety of online tools such as engagement software like simulation which will help students to gain practical exposure in a simulated environment. IITs and NITs use this methodology. The teacher can also use alternate learning modes such as group projects and group presentations using break out rooms inbuilt in teaching platforms. However, since in online mode there is no face to face interaction, the teacher has to

make sure that there is clarity in whatever is being taught through constant feedback.

Evaluation

The major advantage of synchronous learning mode is that live assessments in the form of quiz or multiple choice questions can be conducted where the answers are also promptly displayed. The teacher can conduct presentations and viva and record them so that the students can watch it later to know where they made mistakes.

Learning outcome

Learning becomes more effective when learning happens through various methods. In synchronous model, learning can happen through group tasks leading to group learning, peer learning through discussion mode and practical learning through simulation.

Challenges

The different challenges in synchronous based learning are as follows:

1. Students may have a low attention span as there is no direct interaction.

2. Students may not be on mute creating background disturbance if online etiquettes are not followed. Students may talk amongst themselves and controlling the class may be difficult as the students are not present physically present.

3. The students may switch off their videos and hence there is no way to find out about student expressions and student involvement.

4. If students are not trained on online technologies, teaching – learning process may not be effective.

5. The students may share the passwords with outside mates thereby creating privacy issues.

(ii) Asynchronous model

The major components of asynchronous model of learning are methodology, evaluation, learning outcomes and challenges but they are very different from the synchronous model.

Methodology

The teaching pedagogy encourages students to learn without teacher interaction in their convenient time by viewing class recordings. Hence, the timing of learning is flexible. The asynchronous mode encourages individual learning where one can read or watch the content and learn without any peer interaction. However, the videos provided should be of good quality leading to effective learning. The students can also see recordings of live demonstrations on YouTube or other channels.

Evaluation

In order to make sure that the students have seen the circulated videos, there can be inbuilt assignments which the students will have to complete intermittently while watching the video and submit so that the teacher knows that the student has watched the videos.

Learning outcome

In asynchronous mode, by reading or watching the content repeatedly, learning can be reinforced. Engineering students can view recordings of their lectures again and again and leading to learning through reinforcement.

Challenges

The major challenge in asynchronous learning mode is that the students may circulate copyright material leading to privacy issues.

(iii) Technology challenges

The technology challenges are common to synchronous and asynchronous mode of learning

1. The internet speed should be good else there would be connectivity issues hampering the process of teaching-learning.

2. The technology should be robust to accommodate large number of students in a session without any disturbance else the process of learning will not be effective.

3. The technology should be updated periodically to include new features such as raising a hand to ask for question, presenter rights, class control option, etc. for smooth conduct of the class.

4. The technology should be compatible with multiple devices so that students can attend sessions using mobile phones, tabs and laptops.

7. Implications of the study

Implications for Engineering colleges: In the wake of Covid 19 pandemic, online learning is the way forward in India. The study will help engineering colleges in India and other developing nations to make online learning more effective. They will then be able to decide on the right mix of pedagogical tools to engage with students through synchronous and asynchronous mode leading to effective learning outcomes. This will also result in higher satisfaction towards learning amongst the students. Guest session from faculty who are abroad can be smoothly conducted without any cost. De Guzman (2020) showed that effective learning outcomes result in development of skills.

Implications for policy makers: UGC is encouraging the use of online resources in order to encourage blended learning as part of their policy to save time and money. The study will help them to design "quality assurance" parameters for online learning based on expectations. It will enable them to conduct training programmes for synchronous and asynchronous teaching based on expectations.

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Appendix

Questions asked to respondents

(i) What is your expectation from an online class?

(ii) What is your experience in synchronous mode of online teaching – learning?

(iii) What is your experience in asynchronous mode of teaching-learning?

(iv) Describe your experience with the evaluation of

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In Silico Based Bioinformatics Project During the COVID-19 Lockdown Period: An Alternative to Wet Lab Study

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Abstract: In the weeks and months following the COVID outbreak, millions of students around the world are forced to switch over from traditional classroom learning to online learning. This unprecedented move had tremendous impact on the mode of learning project based courses. In particular, the field of biological science project based courses which require the students and faculty to work in the laboratory was impacted. 5 students and a faculty from Kalasalingam Academy of Research and Education used modern in silico tools, databases and software to study a biological problem related to antibiotic resistance in a bacterium called Enterobacter hormaechei subsp. hoffmannii OIPH-N069. The students used freely available modern bioinformatics tools, databases and software such as NCBI, PROTPARAM, SOPMA, BLAST, CLUSTAL OMEGA, CDD, SWISS-MODEL server, PATCHDOCK, PYMOL and CARD to carry out the research work. This method of doing the project has resulted in the phase I completion of the project course successfully. This methodology of usage of freely available tools, databases and software will help students worldwide to pursue the project based biology courses successfully. The significance of this study is the capability of students in completion of the biology project with the usage of only computer and internet and not to depend upon expensive wet lab study.

Keywords: bioinformatics, in silico, project, computer, COVID

1. Introduction

Modern biological experiments are done using techniques such as microbiology, polymerase chain reaction [1, 2], SDS-PAGE and zymogram analysis [3]. Unfortunately, after COVID lockdown many of the universities and colleges teaching biology based courses faced the difficulty in conducting project based learning courses. In our university, we also faced the similar problem. 5 students from the Department of Biotechnology, Kalasalingam Academy of Research and Education used modern bioinformatics tools, databases and software such as NCBI, PROTPARAM, SOPMA, BLAST, CLUSTAL OMEGA, SWISS-MODEL server, PATCHDOCK, PYMOL and CARD to carry out the research work. NCBI genome database was used by the students for the preliminary searching of the protein sequences.

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The major research objectives of this study is to retrieve the antibiotic resistance determinant protein sequences and to predict primary, secondary, tertiary structures of proteins. Other research objectives included in this study are local and multiple alignment of protein sequences and finding the conserved domains in the protein sequences along with the docking of protein structures with ligands. NCBI (National Centre for Biotechnology Information) was used for retrieving the protein sequences. PROTPARAM tool was used by the students to study the primary structure of protein sequences. SOPMA (Self Optimized Prediction Method with Alignment tool) was used by the students for predicting the secondary structure of protein sequences. BLAST (Basic Local Alignment Search Tool) was used by the students to examine the sequence similarity and identity of protein sequences against the available databases. CLUSTAL OMEGA tool was employed by the students to do multiple sequence alignment and analysis of protein sequences. SWISS- MODEL server was used for automated homology modeling of protein 3D-structures. PATCHDOCK server was used for the docking studies of protein with antibiotic. PYMOL tool was used to see the tertiary structure of proteins. CARD (The Comprehensive Antibiotic Resistance Database) was used for finding out the closest of relative of study proteins. Thus, by using such modern bioinformatics tools, software and databases, the students were successfully able to complete the phase I of the mandatory project work course despite without access to wet lab experiments. We have used the modern bioinformatics tools, databases and software to solve the problem of dependence upon expensive wet lab biology experiments which could not be done during lockdown period as the educational institution is out of bounds for the students due to COVID outbreak.

2. Literature Review

The importance of continuing education in particular biology based course during the COVID-19 pandemic has been a real challenge [4]. Many universities and colleges have reimaged the new pedagogical possibilities post-Covid-19 outbreak [5].The effects of blended and project-based learning are felt post-Covid-19 outbreak [6]. COVID-19 has opened the flood gates for e- Learning based projects [7]. In country such as China where COVID-19 outbreak started, online teaching has been recommended for project based courses [8]. Many strategies have been created by the teachers to engage remote learners in biomedical education after the outbreak [9]. Many universities and colleges have closed due to corona virus disease. This had impact upon education and mental health of students and academic staffs who were unable to continue traditional lab based courses [10]. COVID-19 has come as blessing in disguise and became a catalyst for educational change [11]. Many biology based educational institutions in the world have switched over to e-based projects [12]. In India, COVID-19 had great impact on higher education [13]. Our study is significant because there are no significant earlier published reports where bioinformatics was used for remote learning for project based courses. We have used the modern bioinformatics tools, databases and software which are alternatives to expensive wet lab biology experiments. The existing wet lab facilities are expensive and are out of bounds for students Post-COVID outbreak.

3. Methodology

The NCBI genome database was used by the students for the initial search and retrieval of protein sequences [14]. The primary structural features of protein sequences were analyzed using PROTPARAM tool [15]. The similarity and identity of the protein sequences was determined by the students using BLAST tool [16]. Multiple sequence alignment and motif analysis of protein sequences were done by the students using CLUSTAL OMEGA tool [17]. Conserved Domain Database was employed by the students for searching the conserved domains in the protein sequences [18]. The students predicted three dimensional structures of proteins using Swiss-Model server [19]. PATCHDOCK server was used by the students for the docking studies of protein with antibiotic. Later, the students used PYMOL tool to display the tertiary structure of proteins [20]. Finally, the students used CARD (The Comprehensive Antibiotic Resistance Database) for finding out the closest of relative of study proteins.

4. Result and Discussion

A. Protparam Analysis

The students used the Protparam homepage and FASTA sequence was entered and the parameters were computed. The results were obtained as displayed in the figure [Fig. 1].

Properties	A	B	C	D	E	F	G	H	I
Number of amino acids	712	214	381	284	291	241	347	338	162
Theoretical pI	5.37	8.79	8.74	9.69	8.91	7.74	5.17	5.99	10.47
Stability index (II) value	39.99 (Stable)	45.96 (Unstable)	33.62 (Stable)	27.75 (Stable)	23.94 (Stable)	19.84 (Stable)	38.65 (Stable)	42.96 (Unstable)	33.76 (Stable)
Aliphatic index value	84.33	81.17	87.64	121.87	88.97	95.98	98.33	103.79	144.94
GRAVY value	-0.268	-0.233	-0.045	0.512	-0.199	-0.061	0.057	-0.054	1.013

A-WP_022649503.1 MULTISPECIES: penicillin-binding protein activator

B -WP_085929697.1 MULTISPECIES: penicillin-binding protein activator LpoB

C -WP_022646807.1 MULTISPECIES: cephalosporin-hydrolyzing class C beta-lactamase ACT- 24

D -WP_022647060.1 MULTISPECIES: beta-lactamase regulator AmpE

E -WP_025368620.1 MULTISPECIES: class A extended-spectrum beta-lactamase CTX-M-2

F -WP_032492430.1 MULTISPECIES: subclass B1 metallo-beta-lactamase KHM-1

G -WP_000913396.1 MULTISPECIES: rod shape-determining protein MreB

H -WP_003860400.1 MULTISPECIES: rod shape-determining protein MreC

I - WP_003860402.1 MULTISPECIES: protein rod shape-determining MreD

GRAVY -Grand average of hydropathicity

Fig. 1 : Predicted physicochemical and biological properties of β-lactam resistance determinants and related proteins

B. SOPMA Analysis

The students used the SOPMA homepage and FASTA sequence was entered and the parameters were computed. The following results such as the number of β strands, number of α helices, other percentage and total residues was obtained [Fig. 2].

Protein sequence ID	Number of β-strands (%)	Number of α-helices (%)	Others (%)	Total residues
WP_022649503.1	53(7.44%)	291(40.87%)	368(51.69%)	712
WP_085929697.1	13(6.07%)	80(37.38%)	121(56.55%)	214
WP_022646807.1	21(5.51%)	145(38.06%)	215(56.43%)	381
WP_022647060.1	3(1.06%)	214(75.35%)	67(23.59%)	284
WP_025368620.1	19(6.53%)	141(48.45%)	131(45.02%)	291
WP_032492430.1	18(7.47%)	86(35.68%)	137(56.85%)	241
WP_000913396.1	29(8.36%)	149(42.94%)	169(48.7%)	347
WP_003860400.1	21(6.21%)	123(36.39%)	194(57.4%)	338
WP_003860402.1	5(3.09%)	109(67.28%)	48(29.63%)	162

WP_022649503.1 MULTISPECIES: penicillin-binding protein activator

WP_085929697.1 MULTISPECIES: penicillin-binding protein activator LpoB

WP_022646807.1 MULTISPECIES: cephalosporin-hydrolyzing class C beta-lactamase ACT- 24

WP_022647060.1 MULTISPECIES: beta-lactamase regulator AmpE

WP_025368620.1 MULTISPECIES: class A extended-spectrum beta-lactamase CTX-M-2

WP_032492430.1 MULTISPECIES: subclass B1 metallo-beta-lactamase KHM-1

WP_000913396.1 MULTISPECIES: rod shape-determining protein MreB

WP_003860400.1 MULTISPECIES: rod shape-determining protein MreC

WP 003860402.1 MULTISPECIES: protein rod shape-determining MreD

Fig. 2: Secondary structure summary of the β-lactam resistance determinants and related proteins

C. BLASTp Analysis

BLASTp stands for Basic Local Alignment. The BLAST output can be delivered in a variety of formats.

Protein sequence ID	Sequences producing significant alignments	E-value
WP_022649503.1	Penicillin-binding protein activator(Enterobacter hormaechei)WP_063861684.1	0
WP_085929697.1	MULTISPECIES: penicillin-binding protein activator LpoB [*Enterobacter*] WP_085929697.1	$1e^{-153}$
WP_022646807.1	ACT family cephalosporin-hydrolyzing class C beta-lactamase [*Enterobacter hormaechei*] wp_126490135.1	0
WP_022647060.1	MULTISPECIES: beta-lactamase regulator AmpE [*Enterobacteriaceae*] WP_023299333.1	0
WP_025368620.1	Extended spectrum beta-lactamase CTX-M [*Escherichia coli*] AYD75455.1	0
WP_032492430.1	Subclass B1 metallo-beta-lactamase [*Cellvibrio sp.*] HCS63136.1	$3e^{-146}$
WP_000913396.1	Rod shape-determining protein mreB [*Escherichia coli* CFT073] AAN82446.1	0
WP_003860400.1	Rod shape-determining protein MreC [*Enterobacter hormaechei*] WP_148386311.1	0
WP_003860402.1	MULTISPECIES: rod shape-determining protein MreD [*Enterobacteriaceae*] WP_010436160.1	$1e^{-106}$

WP_022649503.1 MULTISPECIES: penicillin-binding protein activator

WP_085929697.1 MULTISPECIES: penicillin-binding protein activator LpoB

WP_022646807.1 MULTISPECIES: cephalosporin-hydrolyzing class C beta-lactamase ACT- 24

WP_022647060.1 MULTISPECIES: beta-lactamase regulator AmpE

WP_025368620.1 MULTISPECIES: class A extended-spectrum beta-lactamase CTX-M-2

WP_032492430.1 MULTISPECIES: subclass B1 metallo-beta-lactamase KHM-1

WP_000913396.1 MULTISPECIES: rod shape-determining protein MreB

WP_003860400.1 MULTISPECIES: rod shape-determining protein MreC

WP_003860402.1 MULTISPECIES: protein rod shape-determining MreD

Fig. 3: BlastP analysis of β-lactam resistance determinants and related proteins

The students used BLAST for identifying species, and sequence comparison. From BLASTp, the students concluded that the list of hits starts with the best match. E-value represents the expected number of change alignments, the smaller the E- value the better the match [Fig. 3].

D. Multiple Sequence Alignment and Motif Analysis

The students found that H-X-H-X-D motif, a characteristic zinc-binding motif, is present in Multispecies: beta-lactamase regulatory AmpE and Multispecies: subclass B1 metallo beta lactamase KHM-1(wp_022647060.1 and wp_032492430.1). S-X-N motif ,the penicillin binding protein specific motif is present in Multispecies: penicillin binding protein activator and Multispecies: class A extended spectrum beta lactamase CTX-M-2 (wp_022649503.1 and wp_025386201).S-V-V, a motif specific to Class-D β- lactamase, is present in Multispecies: Rod shape determining protein mreD (wp_003860402.1).Y-X-N is the characteristic motif is present in Multispecies: penicillin binding protein activator LpoB and Multispecies: cephalosporin-hydrolyzing class C beta- lactamase

ACT-24 (wp_085929697.1 and wp_022646807.1).K-X-G motif involved in active site function and regulation is present in Multispecies: penicillin binding protein activator and Multispecies: cephalosporin hydrolyzing class C beta lactamase ACT-24 and Multispecies: penicillin-binding protein activator (wp_022649503.1 and wp_022646807.1). S- X-X-K with an active serine known for destroying the beta lactam ring of the antibiotic is present in Multispecies: penicillin binding protein activator (wp_022649503.1) [Fig. 4].

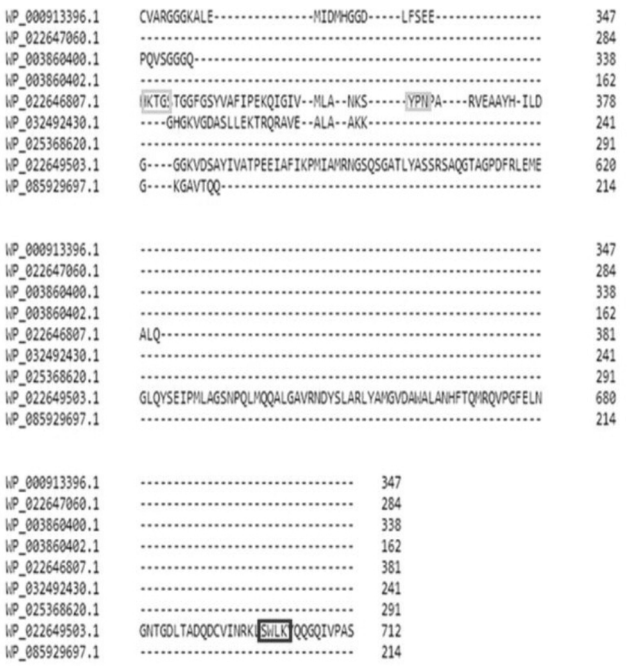


Fig.4:Motif analysis of the beta lactam resistant protein

E. Homology Modelling Analysis and docking studies

The homology model predicted by the students gave the essential structural features namely the α-helix, β structure and an active serine known for destroying the beta lactam ring of the antibiotic. The beta lactamase domain containing proteins had shown greater level of interaction with the penicillin substrate specificity. The interacting side chains are represented as balls and sticks. The sequence alignment and template structure are then used by the students to produce structural model of the target. The accuracy of the structures generated by homology modelling is highly dependent on the sequence identity between target and template [Fig. 5].

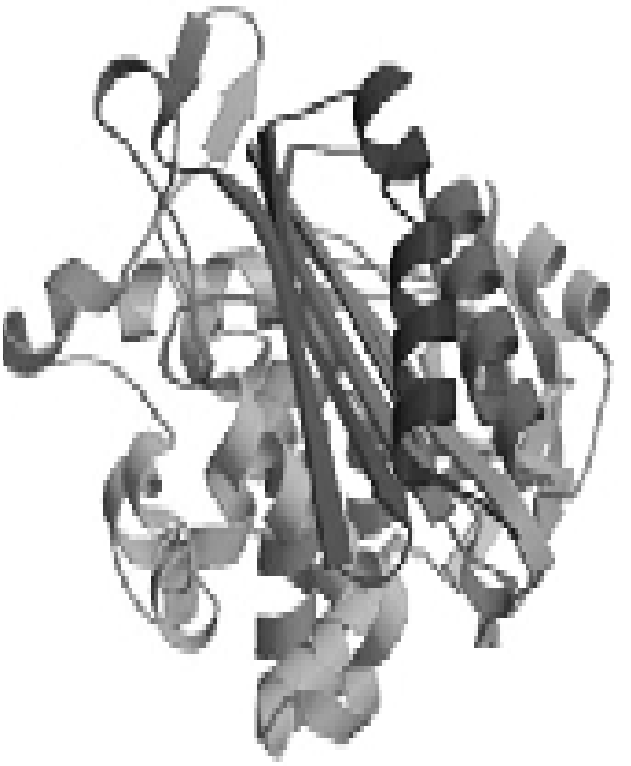


Fig.5 : Three dimensional protein structure of beta-lactam resistant determining protein.

F. PatchDock Analysis

PatchDock uses a geometry based biomolecular docking software. The students gave input as two molecules of protein and antibiotic. The output obtained by the students showed a list of potential protein-antibiotic complexes. The input protein (Receptor) and penicillin (Ligand) in PDB format was uploaded by the students. The protein PDB format was retrieved from the Swiss-model server and the penicillin PDB format was retrieved using Pubchem by the students. The PDB format molecules in the receptor molecule and ligand molecule were readied by the students. The default RMSD value for this parameter is 4.0Å.

A web page that represents the top 20 solutions of docked protein-antibiotic complex was automatically generated. The result was represented in a table. The geometric score, the interface area size and the rigid transformation of the solution were obtained. The PDB file of the protein-antibiotic complex was downloaded as a compressed file contains the top scoring solutions[Fig.6].



Molecular Docking Algorithm Based on Shape Complementarity Principles

[About PatchDock] [Web Server] [Download] [Help] [FAQ] [References]

Receptor	Ligand	Complex Type	Clustering RMSD	User e-mail	Receptor Site	Ligand Site	Distance Constraints
model_011.pdb	tclcactvs0009s8vDy.pdb	Default	4.0	imjashin@gmail.com	-	-	-

Solution No	Score	Area	ACE	Transformation	PDB file of the complex
1	4974	595.60	-170.05	0.44 -1.00 -1.24 8.19 18.87 12.26	result.1.pdb
2	4966	584.40	-116.90	2.88 1.09 1.76 8.20 18.53 13.52	result.2.pdb
3	4700	558.30	-116.56	3.09 -1.00 -1.01 8.02 19.13 15.24	result.3.pdb
4	4524	510.20	-128.34	-1.39 1.17 2.91 7.62 21.39 18.67	result.4.pdb
5	4496	567.50	-235.14	1.61 1.39 -0.20 8.15 16.35 4.49	result.5.pdb
6	4368	497.30	-137.31	-2.70 -1.23 -1.10 7.25 21.63 19.30	result.6.pdb
7	4358	593.30	-228.27	2.06 -1.02 2.90 7.55 15.99 5.60	result.7.pdb
8	4118	577.40	-188.68	-0.04 1.14 1.94 9.19 17.99 10.37	result.8.pdb
9	4058	618.10	-192.28	-2.75 1.14 1.12 8.03 16.43 8.70	result.9.pdb
10	3988	438.50	-144.94	-1.82 0.84 1.17 7.66 24.18 23.54	result.10.pdb
11	3984	433.80	-148.33	2.21 1.13 2.27 5.36 22.58 22.88	result.11.pdb
12	3970	473.90	-216.48	2.82 1.11 2.80 21.31 -3.45 19.23	result.12.pdb
13	3958	589.70	-228.09	1.37 -1.19 -1.81 8.37 17.70 8.76	result.13.pdb
14	3946	488.60	-181.27	0.85 -0.50 -0.02 3.19 22.82 24.01	result.14.pdb
15	3902	467.70	-216.96	0.28 -1.19 -0.56 21.46 -2.91 18.87	result.15.pdb
16	3894	449.90	-156.59	0.10 -1.50 2.78 20.32 -3.63 26.05	result.16.pdb
17	3892	420.70	-114.29	1.83 -0.53 1.00 10.11 24.00 13.27	result.17.pdb
18	3836	433.60	-97.21	0.43 -0.09 -2.44 6.60 16.80 33.62	result.18.pdb
19	3834	465.10	-120.73	1.43 -0.15 -2.10 10.34 22.51 14.22	result.19.pdb
20	3826	409.00	-130.82	-3.10 -0.26 -2.87 -3.10 10.89 31.40	result.20.pdb

Fig.6. Beta-lactamase (WP_022646807.1 MULTISPECIES: cephalosporin-hydrolyzing class C beta-lactamase ACT- 24) docked with penicillin

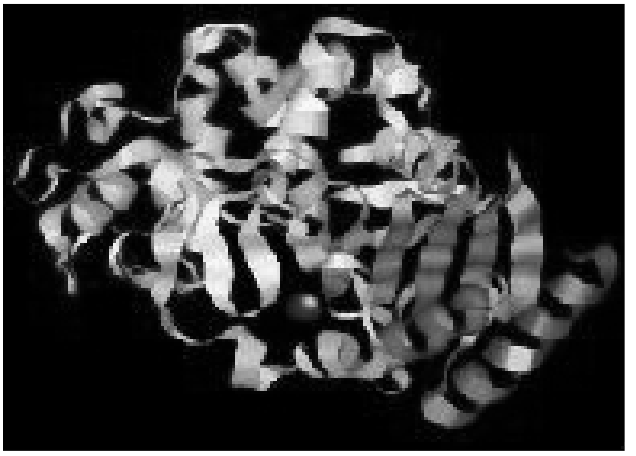


Fig.7: Docking of tertiary structure of beta-lactam resistant determining protein to penicillin.

A. Docking of Beta-lactam resistant protein to penicillin

The students finally concluded the project by docking the beta-lactam resistant protein to penicillin [Fig. 7].

Thus, by using such modern bioinformatics tools, software and databases, the students were successfully able to complete the phase I of the mandatory project work course despite without access to wet lab experiments.

A. Qualitative comparative analysis of in silico bioinformatics and wet lab experiments

The following advantages of bioinformatics were observed by our students over wet lab experiments:

1. Less consumption of time to do the experiment
2. No usage of expensive wet lab consumables
3. Less dependence upon lab resources during the lockdown period
4. Highly statistically significant when compared to wet lab experiments

B. Student feedback of in silico bioinformatics and wet lab experiments

The students were asked to give feedback. All the students were found to be more comfortable with in



Fig. 8: Student performing the experiment in his home with the help of his laptop

silico bioinformatics mode of project as they were able to do the experiment in comfort in their home [Fig. 8]. All the students were able to offer practical solution to the research objectives as evident from the results. All the students were able to manage the time properly.

4. Conclusion

After COVID-19 lockdown, many universities, colleges and schools have adapted technology for teaching, learning and students' engagement [21]. Similarly, our students also have adapted bioinformatics technology for completing the project. There are wide branches of biology oriented courses such as physiotherapy has adapted technology based student research projects during the COVID-19 lockdown [22]. Our students have also adapted the modern bioinformatics tools, databases and software such as NCBI, PROTPARAM, SOPMA, BLAST, CLUSTAL OMEGA, CDD, SWISS-MODEL server, PATCHDOCK, PYMOL and CARD to carry out the research work. NCBI was used by the students as it provides access to biomedical and genomic information. PROTPARAM tool used by the students helped them to compute physical and chemical parameters of the protein. SOPMA tool used by the students helped them to compute secondary structural features of protein. BLAST tool used by the students helped them to identify the similar protein sequences in NCBI database. CLUSTAL OMEGA used by the students helped them to do alignment of multiple protein sequences. CDD was used by the students to identify conserved domains in the protein sequences. SWISS-MODEL server used by the students helped them to automated modeling of protein structure. The students used shape complementarity principles in PATCHDOCK to perform the docking experiments. PYMOL used by the students helped them to visualize the structures of proteins. Like our case study, online teaching-learning in higher institutes of education such as universities and colleges during the lockdown period of COVID-19 pandemic has become common [23]. Similar to our study, information technology has been employed by an institute for IT bachelor capstone project during lockdown [24]. Since, the role of online teaching tools has been important during the lockdown of COVID-19, we also used modern in silico tools for this capstone project [25]. Many secondary school students have also used tool such as citizen science to facilitate practical and online science learning as done by us with help of bioinformatics tools [26]. This method of doing the project has resulted in the phase I completion of the project course successfully. This methodology of usage of freely available tools, databases and software will help students worldwide to pursue the project based biology courses successfully. Moreover, a complex study problem such as antibiotic resistance was studied without spending any chemical reagents and other wet lab requirements. Hence, we suggest the usage of in silico tools for complex research projects such as capstone projects offered by the institutions all over the world. But, we believe that classical wet lab experiments will further enhance our knowledge about the study such as antibiotic resistance in bacteria.

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Case study: An exploratory-descriptive study on the engineering students' perceptions about online assessment during the COVID-19

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Abstract : To ensure high-quality educational processes, more educational research should be developed about student experiences during the COVID-19 pandemic. Furthermore, the student's perception about distance learning education (under the current situation) could be used as input for instructors and educational institutions to guide their distance learning process. The primary aim of this research is to explore engineering undergraduate student's perceptions about the online assessment methods during the COVID-19 age. This paper presents an exploratory-descriptive study based on content and quantitative analysis tools. The main findings of this research concern the factors perceived as the main differences between the face-to-face and online assessment by a group of engineering students during the current pandemic. These factors are: teaching presence, self-efficacy, autonomy, teamwork, and coherence between assessment and class. Furthermore, in the analyzed state-of-the-art, the last three factors have not been reported. These results will be used to guide the improvement of future online assessment methods in our engineering school.

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Keywords: Assessment's methods; COVID-19; Distance Learning; On-line Learning.

1. Introduction

The situation caused by the COVID-19 pandemic forced governmental actions, such as temporary closure of the schools and universities around the world in more than 109 countries (Mahaye, 2020; Syed, Kandakatla, Yadav, & Himasagarika, (2021)). In Colombia, the government decreed a strict quarantine in April 2020, which force the migration from face-to-face to distance lectures by the educational institutions (Ruka, 2020; Sanchez & Ariza, 2020). This abrupt change implied a rapid adaptation process of the educational institutions world-wide (Mahaye, 2020; Syed, Kandakatla, Yadav, & Himasagarika, (2021)). Furthermore, professors and students had to face several pedagogical, technical, financial, or organizational obstacles (Ruka, 2020; Lassoued, Alhendawi, & Bashitialshaaer, 2020; Syed, Kandakatla, Yadav, & Himasagarika, (2021)). Furthermore, some institutions introduce Information and Communication Technologies (ICTs) on a larger scale under the distance learning paradigm (Ruka, 2020; Sanchez & Ariza, 2020;). For instance, in local Universities in Colombia (e.g., Pontificia Universidad Javeriana), both postgraduate and undergraduate courses change from face-to-face to virtual classes, supported by a learning management system (e.g.,

Blackboard or teams software) and other open software tools (e.g., Open Broadcaster Software). Distance learning has impacted not only universities but also elementary schools in Colombia, for instance, the Instituto Alberto Merani implemented ICT tools (i.e., Moodle and Zoom software) to guarantee the access to virtual classes for all their students. This fact has also transcended to educational institutions world-wide as is the case of the, institutions with a very well-known trajectory in the design and implementation of online courses (e.g., Massachusetts Institute of Technology and the Harvard University), which increase their distance learning offer. In this research, we follow the distance learning concept discussed by Lassoued et al. (2020), which define distance learning as an "interactive learning between a teacher and a student that takes place outside the walls of the educational institution, so that information and knowledge from its sources reach the student through technical means and electronic media.". In this sense, it is very similar to the online learning concept adopted by (Mahaye, 2020; Girik, 2020). We considered both definitions as equal in this paper.

In the COVID-19 age, some works have studied several aspects involved in the distance (or online) learning process (Mahaye, 2020; Lassoued et al. 2020; Girik, 2020; Chick et al. 2020; Kaur, Garg, & Kaur, 2021; Piyatamrong, Derrick, & Nyamapfene, 2021; Saripudin, Sumarto, Juanda, Abdullah, & Ana, 2020; Kaur, Garg, & Kaur (2021)). Mahaye (2020) explored the applicability of some distance learning tools to overcome the restrictions associated with the pandemic. The author exposes that distance learning could be effectively implemented only in a digitally developed society. Lassoued et al. (2020) used an exploratory-descriptive methodology to explore the students' perception of the transition to distance learning. Their results indicate that the professors and students faced many obstacles, which could be categorized as self-imposed (e.g., students had to learn to be more autonomous in their learning process) and external obstacles (e.g., the institutions had to develop pedagogical tools to support learning process). Girik (2020) researched about the learners' perception of online learning during a COVID-19 pandemic using a semi-structured interview and a qualitative method. The author found that the adopted distance process has a significant impact on student performance, they also found that online learning is perceived by the learners as a good option during the pandemic. Furthermore, the author found "good" practices perceived by the students as the insertion of voice notes to give instructions in the material implemented by the lecturer in the online learning process. In addition, the author discussed some obstacles of online learning, such as the availability of free internet access, financial issues, and free online learning applications. George (2020) presented the exploration of a classroom-based methodology for distance teaching of digital logic course to engineering students during the pandemic. In this research, the author evaluated the students` performance and found that the proposed methodology increases their performance. Kaur, Garg, & Kaur (2021) explored the student's perceptions about the quality of engineering education through online platforms. The authors used the notions of knowledge gain, concept clarity, assessment, and satisfaction. They concluded that students prefer regular teaching (i.e., the instructor teaches in front of them). Finally, Chick et al. (2020) explored the distance learning (forced by the pandemic) of eminently experiential environments such as the training processes of medical residents. These authors proposed a methodology based on flipped classroom, online practice questions, teleconferencing, telemedicine clinics, procedural simulation, and surgical videos. However, the author did not evaluate its impact on students' performances.

Due to the pandemic and during the first semester of 2020 our engineering school changed from face-to-face to distance classes. However, the pedagogical and educational methodology remained the same. On the one hand, this abrupt change implied a rapid adaptation process for faculty instructors. They had to reconsider their teaching methods and become proficient in the use of ICTs. On the other hand, students had to learn to be more autonomous in their learning process because many of the contents` lectures were asynchronously delivered, and they had to manage their learning process. Also, peer collaboration facilitated student learning and social interaction between peers. Moreover, summative assessments became a key factor in students' satisfaction with their online learning experience. Furthermore, in the routine student`s evaluation of academic processes, they raised criticisms and questions about assessing tools, such as lack of coherence between assessment and class, very complex assigned tasks, and overwork. These critics were focalized on the assessment tools used in the Dynamic Systems Analysis course, which is a second-year course of the electronic engineering program. To understand the educational context, the course's

instructors looked for literature about student's preferences and acceptance of distance assessments under the conditions associated with the COVID-19 pandemic. However, to the best knowledge of the authors, this topic has not been still explored during the COVID-19 pandemic.

Previous research has explored this topic in the pre-pandemic reality (Chyung, Moll, & Berg, 2010; Jimenez et al, 2020; Obando, Palechor, & Arana, 2018a; Shea & Bidjerano, 2010; Khan & Khan, 2019; Cazan & Indreica, 2014). Chyung et al. (2010) approached the role of intrinsic goal orientation, self-efficacy, and e-learning practice in an introductory online engineering class following a quantitative method. They found that higher levels of intrinsic goal orientation and self-efficacy are associated with higher academic achievement. Jimenez et al. (2020) explored the motivation role in math class under face-to-face and blended class. They found that students in face-to-face learning programs had a statistically higher level of interest. Obando et al. (2018a) analyzed teaching presence in a blended learning university course. They found a significant relationship between student satisfaction and presence learning. Moreover, they found that teaching presence was an essential condition for effective online learning environments. Shea and Bidjerano, (2010) examined the relationship between learner self-efficacy and performance in online environments. The authors suggest that learner presence (i.e., self-efficacy and other cognitive, behavioral, and motivational constructs) supports the learner's self-regulation. Khan and Khan (2019) found that students' acceptance increases if the transition from presence to online is gradual. Cazan and Indreica (2014) analyzed the differences between online and traditional assessments using validated questionnaires and a quantitative methodology. The authors concluded that there are no differences in academic performance between the assessment modalities. However, the online students reported higher levels of anxiety and lower levels of self-efficacy.

Considering our engineering school context under the current pandemic, an exploratory-descriptive study about the students' perception of assessment was developed. Its descriptors are summarized below:

· Objectives: This research aims to explore the factors involved in the distance learning assessment under the current pandemic, considering the points of view of professors and students in an engineering school of a Latin American university.

· Research Question: What are the factors involved in the distance learning assessment during the current pandemic from the point of view of engineering students and instructors.

· Methods: This research uses a mixed methodology based on content and quantitative analysis. We applied the content analysis technique to some reflective activities developed by the students and instructors about its assessment experiences (both face-to-face and online) during the pandemic. In addition, the content analysis was applied to semi-structured interviews of the course. From the results, we developed two surveys about the assessment student`s experiences, which results were analyzed using quantitative analysis.

· Population: Students of electronics engineering program at our engineering school during the first semester of 2020.

· Research Limitations: The used sample was limited to three classes of the same course at the electronic engineering program, which means the 13.33% of the total active students of this program (i.e., 475 persons).

· Results: We identify relevant factors perceived as the main differences between the face-to-face and online assessment experiences, which are: teaching presence, self-efficacy, autonomy, teamwork, and coherence between assessment and class.

· Conclusions: The situation of the COVID-19 pandemic is not a factor perceived by the students as a significant difference between their face-to-face and online assessment experiences. However, we found an indirect relationship between the pandemic condition and assessment students' experiences, which is evidenced in some semi-structured interviews and analyzed reports fragments. Moreover, we identified some factors not reported in the analyzed literature perceived by the students as significant in their assessment experiences during the pandemic (Chyung et al, 2010; Jimenez et al, 2020; Obando et al, 2018a; Khan & Khan, 2019; Cazan & Indreica, 2014; Obando, Palechor, & Arana, 2018b), which are teamwork and coherence between assessment and class.

2. Exploratory Procedures

This study applies a mixed research methodology based on a quantitative analysis and content analysis techniques. This approach allows finding general trends and particular details of the context (Bonilla & Sehk, 2005; Raigada, 2002). In particular, This research used the content analysis concept defined by Bonilla & Sehk, (2005), who conceived this tool as the set of analysis-procedures applied to communication-products that allow processing of relevant data on the individuals and their social and contextual conditions. The quantitative analysis was developed using a non-validated instrument constructed for the particular context (based on exhaustive content analysis of reflective tasks and semi-structured interviews). This instrument could be used instead of a universally validated instrument (e.g., scale or psychometric tests) because this research does not attempt to measure some categories of the population. Furthermore, its main objective is to explore and to describe the different perceptions to categorize them.

Following an exploratory-descriptive approach and to explore students' perception about their learning assessment experiences during the first semester of 2020, a few reflective tasks related with face-to-face and online experiences (i.e., synchronous or asynchronous) were applied to engineering students. These students' tasks were: 1) A reflection essay on the evaluation methods, 2) Two lists made by the students with disciplinary and non-disciplinary topics, which were perceived by them as related to its assessing experiences, 3) A short video of reflection on evaluation methods during the pandemic. These tasks were volunteer, submitted by the 36,5% of the sample (i.e., 63 students of the Dynamic Systems Analysis course, which is a second-year course of the electronic engineering program of our university). These students were 68% male, and 31% female. Moreover, two semi-structured interviews were developed with the course instructors about their learning assessment experiences during the pandemic.

The context analysis technique based on deductive and inductive categories was applied to the communicative products (i.e., reflective tasks and semi-structured interviews transcriptions). The deductive categories were defined from the conceptual framework (i.e., the analyzed state-of-the-art) and the inductive ones were defined based on the systematic exploration of the communicative products. As a result, the content analysis allowed defining five inductive and four deductive categories, which are: Autonomy (A), Teamwork (TW), Work under Pressure (WP), Coherence between assessment and Class (AC), Academic Self-efficacy (AS), Teaching Presence (TP), Motivation (M), Participation (PA), Internet Access (IA).

To identify the perception of the students regarding the possible different characteristics between online and face-to-face assessment during the pandemic, and based on the categories found in the content analysis, one descriptive survey (Díaz, 2017) were implemented on the Microsoft Forms®. This survey was split into two questionnaires, named as Face-to-Face Assessment Instrument (FAI) and the Online Assessment Instrument (OAI) with 26 and 29 questions, respectively. In the developed questionnaires, the most used question type was the Likert scale of Agreement/Disagreement, which is illustrated in Fig. 1. On that Likert scale, questions with positive and negative logic were placed. In positive logic, the statement used the same logic of the evidence found in the content analysis. In negative logic, the statement used the inverse logic of the evidence. These two approaches are exemplified in Table I. The list of all agreement/disagreement Likert questions along with their logic were summarized in Appendix A. These questions were mapped to a numerical scale, which is summarized in Table II.

The numerical results were quantitatively analyzed by the Percentage of Agreement or Disagreement (PAD). The PAD of a question was defined as the average value of all students' responses to the question using the numerical scale discussed before, which was multiplied by 100 (question with positive logic) or -100 (question with negative logic). Furthermore, the PAD of a category was defined as the average value of the questions PADs of the category. In the other queries, the frequency Likert scale and single-response selection questions were used. These question types were illustrated in Fig. 2 and Fig. 3.

Table 1:
Example of the logic agreement/disagreement questions

Logic	Evidence	Statement
Positive	"After taking the virtual exam, I realized that I had to study in a different way"	The experience of taking the course virtual exams, made me reflect on my preparation strategies for the exam.
Negative	"The time was not enough for me in the virtual exam"	"The adverse time conditions in the face-to-face exams were greater than those in the virtual exams"

Table 2:
Mapping of the agreement/disagreement likert scale

Logic	Strongly disagree	Disagree	Agree	Strongly agree
Agree	-1	-0.5	0.5	1



Fig. 1: Example of a question with an agreement/disagreement Likert scale.



Fig. 2: Example of a question with a frequency Likert scale.



Fig. 3. Multiple choice question example.

3. Content Analysis Results

From the content analysis of both the students' reflexive tasks and semi-structured interviews applied to the course instructors, we obtained five deductive and four inductive categories, which were listed in Tables III and IV, respectively. From these categories, two instruments were developed (OAI and FAI), the structure of these instruments was summarized in Table V. In addition, in Table VI, the two control questions developed for the surveys were listed.

Table 3 :
Deductive categories found in the content analysis

Source	Category	Definition
Chyung et al (2010)	Academic Self-efficacy (AS)	Recognition of one's own capacities to organize and implement the required courses of action that will produce certain achievements or results.
Obando et al (2018b)	Teaching Presence (TP)	The design, facilitation and orientation of cognitive and social processes, in order to obtain educational results.
Villalpando et al (2020)	Motivation (M)	The degree to which students strive to achieve the academic goals they perceive as useful and meaningful.
Sfard (2008)	Participation (PA)	The process of becoming part of a learning community through class intervention and preparation.
Andersson and Grönlund (2009)	Internet Access (IA)	Having physical access to a communication device and an Internet connection, the reliability of the connection and everything you need to access the full range of content needed to develop a virtual class.

Table 4:
Inductive categories found in content the analysis

Category		Source or Definition or Evidence
Autonomy (A)	Source	Mentioned in 73.91% of the activities
	Definition	Ability to deliberate, be aware, be informed, make choices and take responsibility for action.
	Evidence	Text fragments of the activities: "It is the ability of a person to investigate, learn and make decisions, independent of others." "Fulfill own duties without being reminded by somebody."
Teamwork (TW)	Source	Mentioned in 65.22 % of the activities and in the semi-structured interview with the instructors.
	Definition	Personal readiness and disposition to carry-out activities with peers to achieve common objectives, exchanging information, assuming responsibility, and solving difficulties that arise.
	Evidence	Text fragments of the activities: "To understand the strengths of each member of the group and take advantage of the most of them, to obtain a better performance facing a test, and then to assign activities to each member consistent with the above mentioned".
Work under pressure (WP)	Source	Mentioned in 82.61% of the activities.
	Definition	Ability to work under adverse circumstances and maintain satisfactory levels of effectiveness and compliance
	Evidence	Text fragments of the activities: "It is the abi lity of each individual to perform an activity." "Knowing how to control cognitive abilities correctly when it is working on a stipulated time."
Coherence between assessment and class (AC)	Source	Mentioned in 65.22 % of the activities and in the interview with the instructors.
	Definition	The relationship between evaluative and lectures practices.
	Evidence	Text fragments from the interview: "We all have had a hard time moving from face-to-face modality to virtual modality. Students are unhappy because t hey perceive less quality classes and expect easy exams"

Table 5 :
Structure of perception assessment instruments details

Instrument or Scale	Category								
	AS	TP	M	PA	IA	A	TW	WP	AC
Number of questions in OAI	2	2	4	4	3	3	2	5	2
Number of questions in FAI	2	2	4	4	0	3	2	5	2
Frequency Likert				X					
Agreement/Disagreement Likert	X	X	X			X	X	X	X
Multiple choice					X				

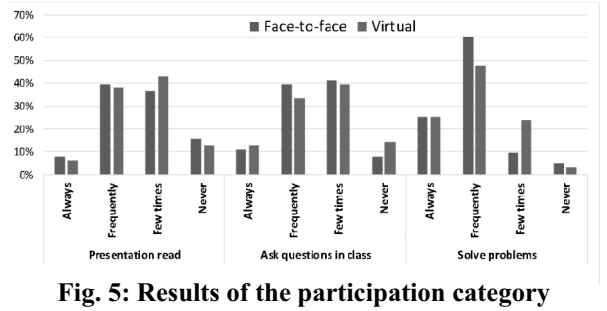


Fig. 5: Results of the participation category related with class participation.

Table 6 :
Control questions used in surveys.

Identifier	Instrument	Question text
P17	FAI y OAI	Adverse time conditions in face-to-face exams were greater than virtual exams.
P19	FAI y OAI	The experience of performing face-to-face exams made me feel high levels of anxiety.

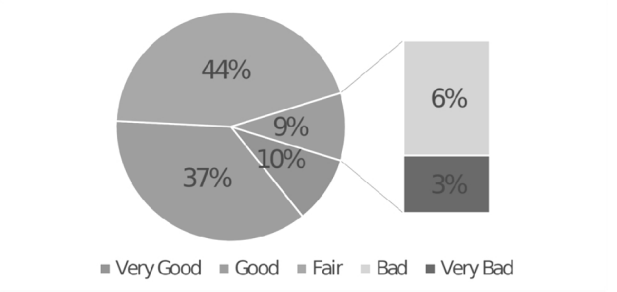


Fig. 4 : Perception of the of Internet Access quality

All the students of the sample (i.e., 63 persons) responded the survey, they are between 18 and 24 years old. The 26.98 %, 71.43 %, and 1.59 % were female, male, and another gender, respectively.

A. Internet access

Regarding internet access (IA), the 92% of the participants had a device to take online classes, and 80% had internet access. Their perception about the IA quality is shown in Fig. 4.

B. Participation

The participation category results were illustrated in Fig. 5 and Fig. 6. Considering these results, the students perceived their participation as frequent and infrequent regarding class preparing activities (e.g., solving the workshops and reading the presentations) and asynchronous online interactions (e.g., forums, short videos, and chat), respectively. Furthermore, there are no differences in the perception of PA category related with class participation between the online and face-to-face modalities, except for the solve problem task, in which more frequent participation was perceived in the face-to-face modality.

C. Quantitative analysis of the rest categories

The agreement/disagreement Likert questions were grouped by categories (see detailed in Appendix A). The analysis of these categories was developed using the PAD concept (explained in the section II). The category PADs were calculated in each instrument (OAI and FAI, which were named as online and Face-to-Face in Figures). The category PADs results were summarized in Fig. 7. These results are coherent with the content analysis because many calculated PADs were positive. This numerical result means that the perception measured quantitatively with the PAD corresponds to the same logic found in the evidence of the content analysis. This trend was valid for all questions, except for questions P9 and P3 of the OAI instrument, with a calculated PAD of -10% and -2% respectively. The calculated PAD difference of the control questions (i.e., P17 and P19) was a maximum value of 10%, therefore the negative values of the PAD (i.e., P9 and P3) could be explained by the instrument error.

To identify the categories perceived by the students as the main differences between their face-to-face and online assessment experiences, the PADs differences of each category were calculated as the mean value of the questions PAD differences of the category. These average values were summarized in Fig 7. Furthermore, the categories with a PAD difference more than 10% (i.e., the estimated error of the instrument) are illustrated comparatively in Fig. 8. These categories (ordered from the highest to the lowest impact in the students` perception) are: teaching presence, teamwork, self-efficacy, autonomy, and coherence between the evaluation and the class

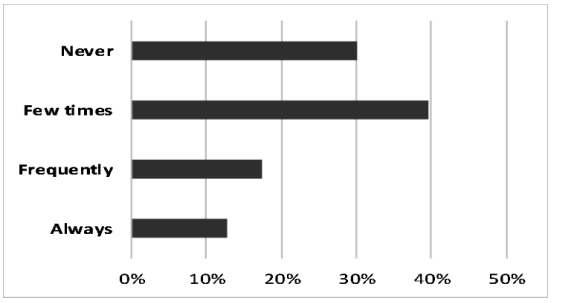


Fig. 6 : Results of the PA category related with the use of asynchronous media.

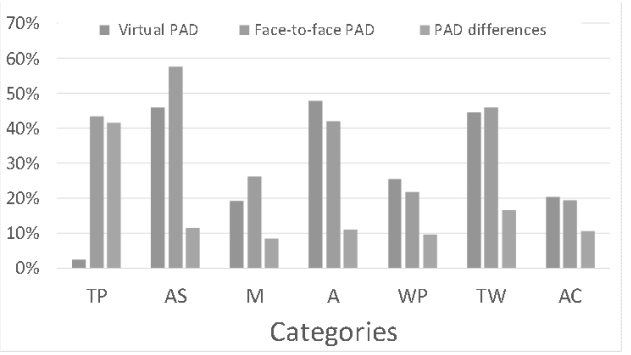


Fig. 7 : Category results and its differences

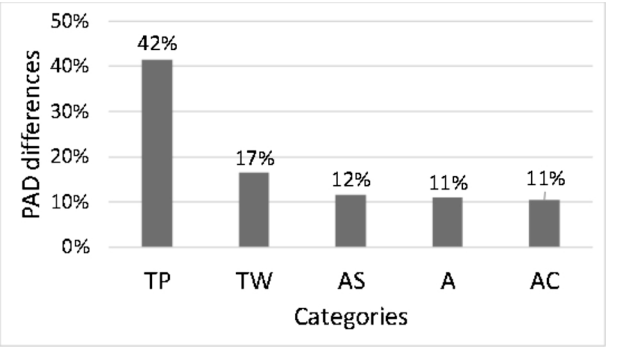


Fig. 8 : Categories with the highest impact in the students` perception

5. Discussion

A. Internet access

The 80% of the students had computers with an internet connection, so this factor did not represent an obstacle to access classes in online mode. This may be related to the private nature of the university and the financial resources of its students. However, the other students (i.e., 20%) had limited their chances of achieving good results in the online model and generated inequality among students. The perception on this topic is exemplified in table VIII through fragments transcribed from the content analysis of the reflective tasks carried out by the students.

B. Participation

The students perceived that they did more frequently its assigned out-class problems in the face-to-face learning process. Furthermore, the decrease in their participation in this task could be linked with the task evaluation method because they perceived the online quizzes as easier than the face-to-face ones. Furthermore, in the online environment, students mentioned that it was easy to find the answer to the evaluations on the internet. Regarding this aspect, the interviewed instructors agreed that student's performance in online quizzes was in general good because they usually had ethical misconducts by interacting with their peers during the individual evaluation activities. Examples of these perceptions are shown in table VIII. Additionally, it was found that the perception of students regarding the use of asynchronous tools available in online education platforms was scarce. This may be related to the students' perception that in the online environment, the work related to the lectures increase under the pandemic. Therefore, they gave priority to the activities linked to the final grade. The above is exemplified in table VIII through fragments transcribed from the content analysis of the reflective tasks carried out by the students.

Table 7 :
Fragments transcribed related to ia and pa

Cat.	Fragments	Actor
IA	"On the other hand, being a tool that needs internet access, for some people who do not have stable access, or they simply do not have fixed internet access, it is very difficult to complete this test, worth almost 50% of the total grade, it is not something that can be despised".	Student
IA	" Not everyone has a good internet connection and the same teams to develop an online exam at the same level".	Student
IA	"I am part of the program. . . and although they told us that they were going to help us with the Internet issue, the only thing they told us was that they were going to recharge us 14 USD in an account so that we have data on our cell phone. But, even so, many of my classmates cannot even access classes at any time, and some (very few) do not have a computer.".	Student
IA	"The faculty did make an effort to try to help the boys, they asked us to identify students who missed a lot of online classes, but after identifying them it was difficult to contact some of them to offer the faculty support".	Instructor
PA	"It was easier to find the answer to the evaluations without developing the exercises".	Student
PA	"In the end, it seemed to me that the boys cheated in the online quizzes, they got good grades, but they didn't participate in the solution ... other teachers showed me that it was easy to cheat on this type of platforms".	Instructor
PA	"It is not a joke to say that many teachers due to the situation are saturating students with many files to read and perform, due to the issue of autonomy".	Student
PA	"In my case, it was necessary to take the time from other assigned work of other classes to develop the exam, this time was vital for achieving a good exam result. However, this effort affected my grade in the other classes."	Student
PA	Although the exam is created according to the time established for its development, it can be considered that it was a bit extensive since it was not taken into account that the student has to answer for other subjects and could not be devoted all the time.".	Student

C. Quantitative analysis of the rest categories

Of the nine categories found in the content analysis, seven categories were analyzed quantitatively. Considering the survey results, only five of them were perceived by the students as the main differences between its face-to-face and online assessment experiences. A brief discussion about student's perceptions of these categories is presented below.

· Teaching presence (TP): The students perceived the physical presence of the instructor in the assessment as more comfortable. One of the reasons is because they consider that face-to-face communication (with the instructor) during the assessment helps them to increase their knowledge (in the assessed topics). This was evidenced in the high difference in the PADs of questions P9 and P3, and in the content analysis. Examples of these perceptions are summarized in table IX.

· Teamwork (TW): The students perceived peer collaboration during the assessments (online and face-to-face) as a tool, which helps them consolidate their knowledge and helps to increase their confidence in obtaining a successful result. However, the peer collaboration interaction was perceived as more important in face-to-face than in online assessment to strength their knowledge. This is evidenced in the value of the PAD difference of the question P4 (in both instruments). The perception on this topic is exemplified in table IX. Additionally, the PAD difference found in P14 question showed that the peer collaboration was perceived as more important in face-to-face than in online assessment to increase the confidence in obtaining a successful result. Examples of these perceptions are summarized in table IX.

· Academic Self-efficacy (AS): Considering the category PAD difference, its definition, and its PAD related question, the students perceived that the two assessment types (especially the face-to-face one) contributed to identify aspects necessary to obtain good academic results, such as study techniques, attitudes, and academic skills.

· Autonomy (A): Considering the category PAD difference, its definition, and its related PAD question, the students perceive that the strategies required to prepare the online and face-to-face assessments are different.

· Coherence between the Assessment and the Class (AC): Considering the category PAD difference, its definition, and its related PAD question, the students perceive that in an online environment the assessments were less complex than in a face-to-face environment.

B. Perception of conditions associated with the COVID-19

Only a few mentions regarding the COVID-19 pandemic were found in the content analysis. The students' perception of the pandemic effects involved in their learning process was grouped in two dimensions. The first dimension is related to the abrupt change from face-to-face to online educational process because the pandemic. The second one is related to the increase and decrease of their anxiety and motivation, respectively. These dimensions are exemplified in the fragments showed in table X.

Table 8 :
Fragments transcribed related to tp and tw categories

Cat.	Fragments	Actor
IA	"On the other hand, being a tool that needs internet access, for some people who do not have stable access, or they simply do not have fixed internet access, it is very difficult to complete this test, worth almost 50% of the total grade, it is not something that can be despised".	Student
IA	" Not everyone has a good internet connection and the same teams to develop an online exam at the same level".	Student
IA	"I am part of the program. . . and although they told us that they were going to help us with the Internet issue, the only thing they told us was that they were going to recharge us 14 USD in an account so that we have data on our cell phone. But, even so, many of my classmates cannot even access classes at any time, and some (very few) do not have a computer.".	Student
IA	"The faculty did make an effort to try to help the boys, they asked us to identify students who missed a lot of online classes, but after identifying them it was difficult to contact some of them to offer the faculty support".	Instructor
PA	"It was easier to find the answer to the evaluations without developing the exercises".	Student
PA	"In the end, it seemed to me that the boys cheated in the online quizzes, they got good grades, but they didn't participate in the solution ... other teachers showed me that it was easy to cheat on this type of platforms".	Instructor
PA	"It is not a joke to say that many teachers due to the situation are saturating students with many files to read and perform, due to the issue of autonomy".	Student
PA	"In my case, it was necessary to take the time from other assigned work of other classes to develop the exam, this time was vital for achieving a good exam result. However, this effort affected my grade in the other classes."	Student
PA	Although the exam is created according to the time established for its development, it can be considered that it was a bit extensive since it was not taken into account that the student has to answer for other subjects and could not be devoted all the time.".	Student

Table 9: Fragments transcribed related to the COVID-19 Pandemic

Fragments	Actor
". . . the learning methods were very different, initially normally with face-to-face classes, but with the arrival of the coronavirus, the work changed a lot. . . This affected learning because now the environment was different, there were more distractions, it was more difficult to pay attention in class. And clearly, this affected evaluation times.".	Student
The sudden change to a new education methodology which we must quickly adapt. The need of attending to our elderly relatives. Also, to maintain the motivation which we started from the beginning of the semester, which has decreased considerably due to various reasons, such as extra occupations, the social confinement, etc.".	Student
"In my case, th is on-line method has generated many stressful situations and has reduced my desire to learn in a significant way, each day involves a new and increasingly stronger challenge, where I have to fight with myself to be able to go through this last trail with a lot of strength and motivation".	Student
"I can also say that this current situation has not been the same for everyone, each one has handled it in their own way. . . being in the same place all the time without being used to this. . . having a greater academic and emotional load, have been factors that are reflected in the academic performance of each student".	Student

Table 10 : Comparison by categories with a brief state-of-the-art.

Study\Cat.	Category								
	TP	TW	AS	A	AC	WP	M	P	IA
This Work	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chyung et al (2010)	No	No	No	Yes	No	No	No	No	No
Cazan and Indreica (2014)	No	Yes	No	Yes	No	No	No	No	No
Khan and Khan (2019)	No	Yes	No	No	No	No	No	No	No
Jimenez et al (2020)	No	No	No	Yes	Yes	No	Yes	No	No
Obando et al (2018b)	Yes	No	No	No	No	No	No	Yes	No
Shea and Bidjerano (2010)	Yes	No	No	Yes	No	No	No	No	No

*Yes, it means that this category was analyzed in the study.
**No, it means that this category was not analyzed in the study.

Table 11 : Comparison by categories with a brief state-of-the-art.

Study	Analysis	Instruments	Val. Tools	Population	Analyzed Dimension
This work	Mixed	Survey	No	Undergraduate	Students' perceptions of face-to-face and virtual assessment methods during the COVID-19 pandemic.
Chyung et al (2010)	Quantitative	Questionnaires	Yes	Undergraduate	The role of intrinsic orientation and self -efficacy in virtua l learning.
Cazan and Indreica (2014)	Quantitative	Questionnaires	Yes	Under	Differences between online and traditional assessment.
Khan and Khan (2019)	Qualitative	Focus groups	No	Under	Preferences and acceptance of online assessments.
Jimenez et al (2020)	Quantitative	Questionnaires	Yes	High School	Motivation towards mathematics in mixed and face -to-face modality.
Obando et al (2018b)	Qualitative	Data and texts	No	Under	Teaching presence in a university course with blended learning modality.
Shea and Bidjerano (2010)	Quantitative	Questionnaires	Yes	Online Students	Statistical Relationship between student self - efficacy measures and their grades.

F. Comparative analysis with a brief State of the Art.

Our work is compared in Tables XI and XII with some other studies with populations and dimensions related to this research. Furthermore, Table XI summarizes the categories explored by the analyzed literature regarding assessment. Considering these tables, our research explored multiple assessment dimensions under the pandemic context. Our results complement and partially confirm some results reported in the literature and can be used to guide the implementation of future assessment methods during the pandemic.

6. Conclusions

The main findings of this research concern the factors perceived as the main differences between the face-to-face and online assessment by a group of engineering students during the current pandemic. These factors are: teaching presence, self-efficacy, autonomy, teamwork, and coherence between assessment and class. Although conditions associated with the COVID-19 pandemic affected students and could influence their assessment perception, they did not perceive the pandemic as a factor that directly influences their assessments processes. However, students perceived its effect as an indirect impact on their motivation. We summarized below other findings of our research, in which we identify an improvement opportunity.

· Teaching presence was the factor perceived by students as the main difference between face-to-face and online assessment. Therefore, our recommendation is to incorporate cognitive and

affective aspects related to teaching presence (e.g., student autonomy, collaborative work, interaction spaces between instructors and students) in the online evaluation. In particular, we recommend the instructor's presence during the online assessment using ICT tools such as chat.

· On one hand, the students perceive teamwork (especially in online assessments) as significant support for cognitive and emotional levels. On the other hand, the instructors perceive teamwork as a useful tool for reducing fraud and increasing students' self-efficacy. Consequently, our recommendation is to promote team assessments and collaborative assessments in the program curriculum.

· In the online environments, students perceived self-efficacy and autonomy as factors impacting their evaluation performance. Thus, promoting assessments, projects, and challenges that involve a gradual increment in complexity could increase the student's perceived self-efficacy and independence.

· According to the students' perception and to increase their participation, it is necessary to adjust the dedication time of the asynchronous online activities to the one defined by the academic credits in the program curriculum. Therefore, our recommendation is to explore in this course and other ones the validity of this perception and, if necessary, redistribute the academic activities consistent with the program curriculum.

7. Future Work

In the next academic period, we will apply the OAI and FAI instruments (developed in this research) to evaluate the students' perception evolution using a new assessment approach guided by the findings summarized in this paper. In addition, following the same methodology, we will explore the students' perception of others courses dynamics, such as the real impact of the course in the development of the curriculum soft skills.

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Appendix

In this appendix, the questions analyzed quantitatively in this research are summarized below in Tables A and B.

Table A
List Of First Ten Questions Analyzed Quantitatively.

ID	Cat.	Logic	Question text
P1	A	Positive	The experience of taking the course virtual exams, made me reflect on my preparation strategies for the exam.
		Positive	The experience of taking the course's face-to-face exams made me reflect on my preparation strategies for the exam.
P2	AS	Positive	The experience of taking the virtual exams allowed me to identify the aspects (study techniques, attitudes, skills) that I must maintain to obtain good results in this course.
		Positive	The experience of taking face-to-face exams allowed me to identify the aspects (study techniques, attitudes, skills) that I must maintain to obtain good results in this course.
P3	TP	Negative	During the virtual exams, my communication with the teacher helped me to increase my knowledge about the assessed topics.
		Positive	During the face-to-face exams, my communication with the teacher helped me to increase my knowledge about the assessed topics.
P4	TW	Positive	Working with my classmates during the virtual exams helped me to consolidate my knowledge about the assessed topics.
		Positive	Working with my classmates during the face-to-face exams helped me to consolidate my knowledge about the assessed topics.
P5	M	Positive	The experience of taking the virtual exams seemed useful to my academic training.
		Positive	The experience of taking the face-to-face exams seemed useful to my academic training.
P6	AC	Positive	To solve the virtual exams successfully, a great intellectual effort was necessary because the knowledge built in the virtual class was insufficient.
		Negative	To solve the face-to-face exams successfully, a great intellectual effort was necessary because the knowledge built in the face-to-face class was insufficient.
P7	WP	Positive	The experience of taking the virtual exams, made me feel that I can work under adverse time conditions while efficiency is maintained.
		Positive	The experience of taking the face-to-face exams, made me feel that I can work under adverse time conditions while efficiency is maintained.
P8	M	Positive	I was motivated to present the virtual exams because I liked the topics that were assessed.
		Positive	I was motivated to present the face-to-face exams because I liked the topics that were assessed.
P9	TP	Negative	During the virtual exams, I felt comfortable with the virtual presence of the teacher.
		Positive	During the face-to-face exams, I felt comfortable with the physical presence of the teacher.
P10	A	Positive	Strategies for preparing virtual exams are different from preparing face-to-face exams
		Positive	Strategies for preparing face-to-face exams are different from preparing virtual exams.

Table B
List Of Last Ten Questions Analyzed Quantitatively.

ID	Cat.	Logic	Question text
P11	M	Positive	The experience of taking virtual exams, made me more confident in my skills as an electronic engineering student.
		Positive	The experience of taking face-to-face exams, made me more confident in my skills as an electronic engineering student.
P12	WP	Positive	The experience of taking virtual exams, made me feel that I can work under adverse conditions for activities overload, maintaining efficiency.
		Positive	The experience of taking face-to-face exams, made me feel that I can work under adverse conditions for activities overload, maintaining efficiency.
P13	A	Positive	The experience of taking the virtual exams of the course, made me reflect on my strategies for taking exam.
		Positive	The experience of taking the course's face-to-face exams made me reflect on my strategies for taking exam.
P14	TW	Positive	Working with my classmates during the virtual exams made me feel more confident about a successful outcome.
		Positive	Working with my classmates during the face-to-face exams made me feel more confident about successful outcome.
P15	AC	Negative	Knowledge developed in virtual classes are deep and must be assessed with complex virtual exams.
		Negative	Knowledge developed the face-to-face classes are deep and must be assessed with complex face-to-face exams.
P16	AS	Positive	The experience of taking the virtual exams allowed me to identify aspects (study techniques, attitudes, skills) that I must change to obtain good results in this course.
		Positive	The experience of taking face-to-face exams allowed me to identify aspects (study techniques, attitudes, skills) that I must change to obtain good results in this course.
P17	WP	Negative	The adverse time conditions in the face-to-face exams were greater than virtual exams.
		Negative	The adverse time conditions in the face-to-face exams were greater than virtual exams.
P18	M	Positive	I was motivated to present the virtual exams because I like the virtual assessment methodology.
		Positive	I was motivated to present the face-to-face exams because I like the face-to-face assessment methodology.
P19	WP	Positive	The experience of taking face-to-face exams made me feel high levels of anxiety.
		Positive	The experience of taking face-to-face exams made me feel high levels of anxiety
P20	WP	Positive	The adverse time conditions of activities overload in the virtual exams were greater than face-to-face exams.
		Negative	The adverse conditions of activities overload in the face-to-face exams were greater than virtual exams.

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Effect of Virtual Activity and Game-Based Learning Techniques in Effective Teaching of 'Professional Ethics'Course

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Abstract: COVID-19 pandemic has created a need for adapting to online teaching, making this the era of Digital Pedagogy. The switch to the online mode makes tutors not use their usual chalk and board methods, creative flashcards, charts, models and creates urges to switch for online materials. Professional ethics is a common humanities course across all engineering courses offered in multiple Engineering educational Institutions. This course requires more activity and game-based learning than formal lecturing for understanding the basic concepts. This article illustrates the list of various online tools and their roles in interactive teaching for this course. The implementation and impact of this teaching-learning technique to this course were discussed here briefly. Based on the student feedback from the 36 Biotechnology undergraduate students who learned this course under this method it was clear that the learning environment was more interactive and engaging. Thus, based on the learning outcome observed at the end of this course, it was evident that the use of such a teaching method helps the learners have more interaction and learning. The faculties and institutions offering this course could adapt similar teaching practices to enhance their teaching-learning process.

Keywords: Gamification, Professional ethics, Activity based learning, Online class

1. Introduction

The education industry is the one that got a huge evolution due to the impact created by the COVID-19 pandemic. The teaching-learning process was switched over to online mode putting both the tutors and learners in a blindfolded situation. To meet this circumstance, the teaching community is putting out its full effort by learning and implementing various online tools and techniques in their online lecture sessions (Mishra et al., 2020). The ultimate goal for all these tutors is to achieve effective teaching-learning for their courses.

There are many online teaching platforms and tools available to create an effective learning atmosphere. But the selection of the right tools and implementation of the same is the challenge for the tutors (Bailey and Lee, 2020). The 'Professional Ethics' course has been offered as compulsory course to undergraduate engineering students in almost all the premier engineering institutions of India (Sethy, 2017). In this article, we have highlighted and outlined the above-mentioned online tools concerning

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the implementation of these tools made for the course 'Professional Ethics'. Irrespective of the various meeting platforms used for online classes, the way of presentation matters the most for achieving a better learning environment. The use of interactive presentation, online tools like Pear Deck, Mentimeter and Google spreadsheets has shown increased learner interest during the class sessions. Also, for performing interactive activities and virtual games, there are multiple online portals available specifically for this course.

2. Need for activity and game based teaching and learning

The era of passive learning is over and now it's the era of active learning (Roberts, 2019). The current generation students have multiple options to learn a course such as Coursera, edX, NPTEL, Youtube, etc., (Aithal and Aithal, 2016). So, it puts a new task in front of the faculty, as they have to go the extra mile to attract students to their classes. Besides this, the current generation students have less interest in lectures and they need more hands-on sessions (Haseeb, 2019). Thus the regular classes themselves need more activity and game-based learning.

Nowadays, online classes can be stressful and less interesting for students if it doesn't handle properly. Thus, it's the utmost responsibility of the faculty handling the course to make every online session more interesting and interactive. To create interest in the course we need to move out of our comfort zone of just lecturing and start working on conducting more online activity sessions for the participants. If we share or conduct online activities and online games relevant to the topics, the students may start participating in your classes more actively. When active participation is established then the effective learning of the topics happens automatically.

3. Course Design and Implementation

The Professional Ethics course was offered to the third year B.Tech students as a humanities elective course that carries 3 credits. Around 36 students undertook this course in online mode which was offered by the author. The course consists of 5 modules with 9 hours of teaching for each module leading to a total duration of 45 hours to complete this course. The course had a total of 5 Modules with each module containing various topics which is listed in the Table 1.

Table 1 : Module and Topics

Module No.	Topics
1	Functions of Being a Manager, Skills of a Manager, Stock hol der and stakeholder management, Ethical treatment of employees, ethical treatment of customers, supply chain management and other issues.
2	Senses of Ethics, Moral dilemmas , Moral Autonomy, Kohlberg's theory , Gilligan's theory, Consensus and Controversy , Professions, Professional ideals and virtues , Theories about right action, Self-interest, Customs and religion, Use of Ethical Theories
3	Corporate social responsibility - Collegiality and loyalty , Respect for Authority , Collective Bargaining, Confidentiality, Conflicts of Interest, Occupational Crime , Professional Rights, Employee Rights , Discrimination, Whistle Blowing
4	Moral imagination, stake holder theory and systems thinking, One approach to management Decision, making Leadership
5	Multinational Corporations , Environmental Ethics, Computer Ethics , Weapons Development, Engineers as Managers, Consulting Engineers , Engineers a s Expert Witnesses and Advisors, Moral Leadership, Sample code of conduct

The learning objectives for this course are described below:

1. Students will understand the importance of values and ethics in their personal lives and professional careers.

2. The students will learn the rights and responsibilities.

3. Students will realize the responsibilities of employee, team member and a global citizen.

4. Students will develop leadership qualities and able to identify various stakeholders of a organization.

A. Planning of Virtual Activity based Sessions

The virtual activities planned with its corresponding topics and tool is provided in the below Table 2.

Pear Deck

It is an add-on used with Google slides. It is a powerful interactive presentation tool that allows real-

Table 2 : Virtual Activities

Module No.	Topic from the Module	Tool used for Activity
1	Functions of the Manager	Pear Deck (Scenario discussion)
1	Responsibility towards employee	Mentimeter (QA session)
1	Stakeholder Management Plan	Pear Deck (Scenario discussion)
1	All Topics	Puzzle.org (Crossword Puzzle) Wheel of Names (Pick Student for Interaction)
2	Senses of Ethics	Pear Deck (Scenario discussion)
2	Theories about right action	Pear Deck (Scenario discussion)
2	All Topics	Puzzle.org (Crossword Puzzle) Wheel of Names (Pick Student for Interaction)
3	Respect for Authority	Mentimeter (QA session)
3	Whistle Blowing	Pear Deck (Scenario discussion)
3	All Topics	Puzzle.org (Crossword Puzzle) Wheel of Names (Pick Student for Interaction)
4	Stakeholder theory	Pear Deck (Scenario discussion)
4	All Topics	Wheel of Names (Pick Student for Interaction)
5	Multinational corporations	Mentimeter (QA session)
5	Engineers as managers	Pear Deck (Scenario discussion)
5	Computer Ethics	http://ethicsonlineireland.weebly.com/online-ethics-game.html
5	All Topics	Wheel of Names (Pick Student for Interaction)

time slide sharing with the participants (Javed and Odhabi, 2018). The facilitator can choose an instructor-paced activity if he wants to regulate or control the flow. The other option is a student-paced activity where the individual students can perform the activities at their speeds. In this course, we used this tool to create interactive Q&A sessions based on scenarios specifically for the topic. The key feature of this tool is this can be linked with our Google slides presentation, hence doesn't require moving out of the presentation. Some of the sample Pear Deck slides images used for this course are given below in Fig. 1 and Fig. 2.

Mentimeter

Mentimeter is an online polling tool. It is used to conduct online polls, Word cloud, and MCQ questions live (Rudolph, 2018). The one drawback of this tool

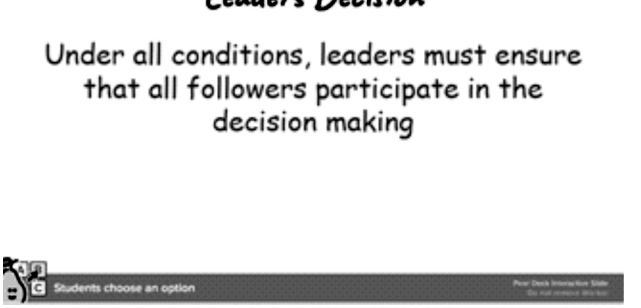


Fig. 1 : Sample Interactive question slide using Pear Deck add-on

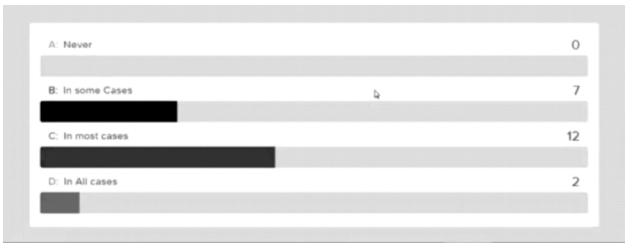


Fig. 2 : Sample Interactive student response slide using Pear Deck add-on

comparing with Pear Deck is that we need to break out of the presentation to use this. But one extra feature we have here is the presence of word cloud formation. Few sample Mentimeter poll images used for this course are given below in Fig. 3 and Fig. 4.



Fig. 3 : Sample Interactive question slide with rating



Fig. 4 : Sample Interactive question slide with word cloud answer option using Mentimeter tool.

Puzzle.org

Crossword puzzles help tutors to evaluate the learning level of their students, especially in a theory course (Zamani et al., 2021). It also makes them curious while solving the puzzle, which makes this evaluation a fun based activity. In virtual class, we can use 'puzzle.org' - an online crossword puzzle maker to create your crossword puzzle. This tool gives an excellent appearance and simple organization. Some of the sample crossword puzzle used for this course is provided below in Fig. 5.

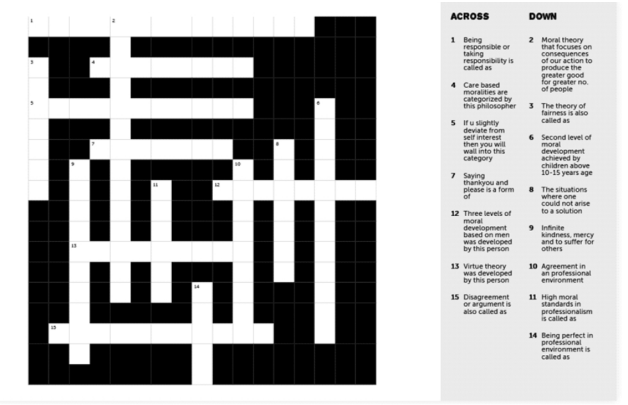


Fig. 5 : Sample crossword puzzle prepared for Module 2 via puzzle.org tool.

Wheel of Names

Randomly picking a student to respond during the online class becomes tricky, as it may feel biased sometimes for the students (Vargas Luna, 2018). So to avoid this, we can make use of this spin wheel link https://wheelofnames.com/. In this, we can save our students list, and during the time of conducting activities or Q&A sessions, we can use this to pick students from the class. It rules out bias and also makes it fun for the students to participate in classroom activities. The sample image of the tool is given below in Fig. 6.



Fig. 6 : Homepage of wheelofnames.com tool to create spin wheel with student names

Table 3 : Online Game Activities

Module No.	Topic from the syllabus	Online game links
1	Stakeholder Management	http://bioteamsapps.com/netsim/netsims/ken.thompson/scg_demo/index.html
1	Supply Chain Management	https://forio.com/app/showcase/near-beer-game/ https://beergame.masystem.se/game/-MSa0k2rvv-LXSrSsbrL
2	Moral Dilemma	https://www.moralmachine.net/
3	Discrimination	http://playfairplay.org/
3	Loyalty	https://www.mission-us.org/games/prisoner-in-my-homeland/
4	Making leadership	https://www.mission-us.org/games/a-cheyenne-odyssey/
4	Moral Imagination	https://www.mission-us.org/games/city-of-immigrants/
5	Environmental ethics and Moral leadership	https://www.quandarygame.org/

B. Planning of Game based Sessions

The virtual activities planned with its corresponding topics and tool is provided in the below Table 3.

Online Games

Playing games is an easy way to grab students' attention. Gamification has proved to be effective in creating an interactive learning environment. The students learn and understand the concepts conveniently by this gamification (Zainuddin et al., 2020). Pinterest and multiple resources sharing websites are available to track and find the best online game matching your topics. But a prior preparation is needed to implement this in the classroom to get better effect.



Fig. 7 : Sample clip from the online game - 'The Beer Game' used for the topic 'Supply Chain Management'

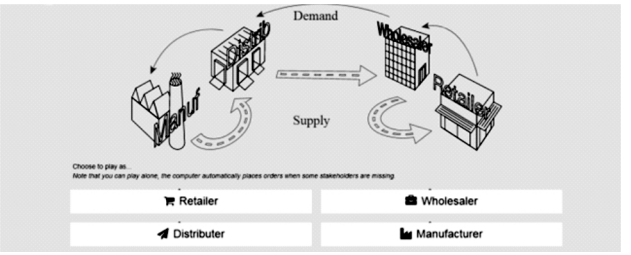


Fig. 8 : Sample clip from the online game - 'MA systems Beer Game' used for the topic 'Supply Chain Management'



Fig. 9 : Sample clip from the online game - 'Fair Play' used for the topic 'Discrimination'

C. Teaching Methodology

When we plan to implement the virtual activities and gamification then the teaching and learning methodology also must change. The contents and slides have to be prepared accordingly. The online class should be pre-planned very well based on the activity/game:

1) Activity sessions: To conduct the activities, we need to keep the required tabs open before initiating the session to avoid any issues. Plan your narration for handling the activities. Make your students first understand the objectives behind the exercises. If it's an individual activity, then select students using the spin wheel to participate in that. At the end of each exercise, explain the takeaway points correlating with the topic.

2) Gamification: Online games and simulations have to be evaluated by you once before trying it outlive. The best practice is to play the game by yourself once and plan accordingly for the live session. Explain the concepts related to your topic in between the games and proceed further. You can share the link with your students and ask them to play and can ask them to share the screenshots.

4. Students reflection on this course

A survey on the impact of activity and gamification methods in the teaching-learning process was collected from all 36 students. The survey consisted of a total of 5 questions, as mentioned below, and its corresponding responses are also given:

Q1. Which of the following online tool was most helpful and effective in creating an interactive learning atmosphere for this course? (Check all that apply).

The responses from the participants for this survey question Q1 is depicted as a Bar graph as shown in Fig. 10.

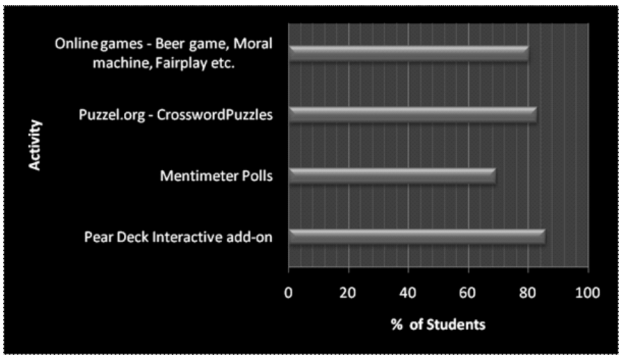


Fig. 10 : Response of participants for Survey Question #Q1 on activity tools

From Fig 10, it was evident that around 86 percent of students felt that Pear Deck was the most helpful and effective tool to create an interactive learning atmosphere for this course. We can also get to know that around 80 percent of the students mentioned that the online games were also equally effective. Also,

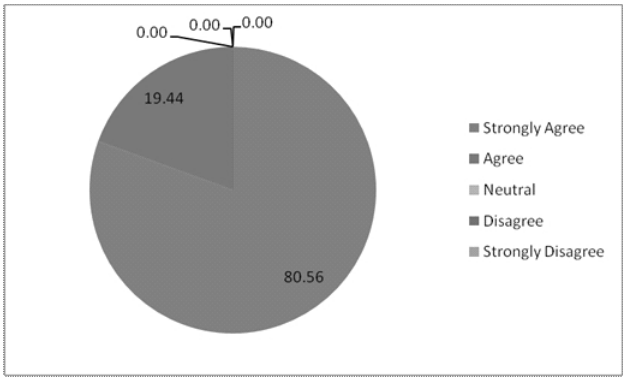


Fig. 11 : Response of participants for Survey Question #Q2 on learning objectives

around 83 percent of students felt that crossword puzzles were also helpful for interactive learning. The Mentimeter polls have been mentioned by around 70 percent of the students.

Q2. The activity and gamification methods helped in achieving the course learning objectives at the end of this course. The response from the participants for this survey question number Q2 is depicted in Fig. 11.

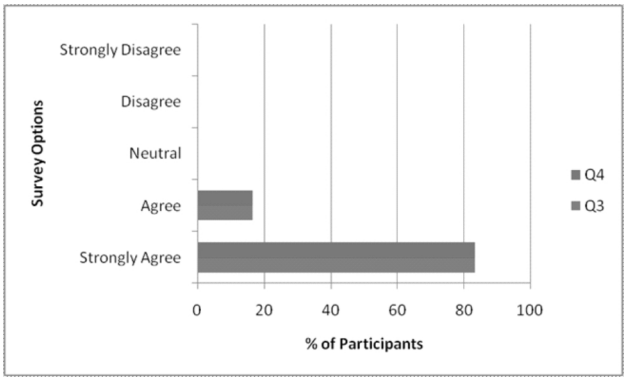


Fig. 12 : Response of participants for Survey Question Q#3 and #Q4 on blended learning on interactive learning and interest in course

From Fig.11, we can know that about 81% of the students have strongly agreed and the remaining 20% has agreed that the activity and gamification methods adapted in this course helped them in achieving the course learning objectives at the end of this course.

Q3. The combination of regular lecturing with activity and game based teaching – learning method helped to create an interactive learning atmosphere.

Q4. The use of activity and game based teaching – learning method helped to create an interest towards this course. The responses from the participants for this survey question number Q3 and Q4 are depicted in Fig 12.

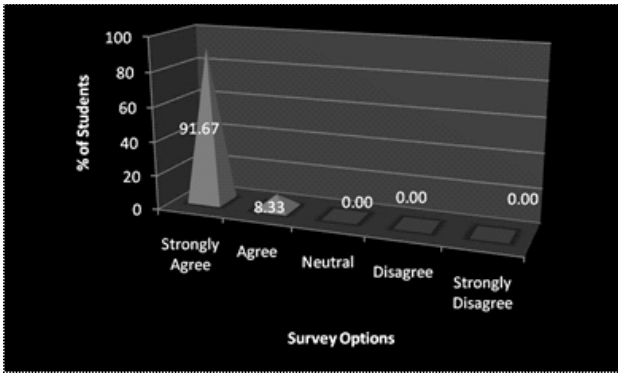


Fig. 13 : Response of participants for Survey Question #Q5 on recommendation of course for future learners

About 92% of the participants strongly agreed and 8% agreed and which implies that all the students recommend this course for future learners.

5. Conclusions

Participants of the course 'Professional Ethics' under this activity and game-based learning method have mentioned through survey a significant achievement in their learning objectives and experienced effective classroom interactions. This methodology inculcates interest in the learners towards the course and makes it simple to grasp the concepts. There is a lot more preparation when one wants to incorporate virtual activities in lessons when compared to the traditional lecture or tutorial sessions. The faculties and institutions offering similar courses could try such approaches to enhance their teaching-learning process, especially for virtual classes. It is a small-scale study with only 36 students from one sample site. It will be best not to claim that the findings can be generalized to other courses/countries due to the size of the samples. The teaching methodology incorporated in this study was planned for a virtual environment. Thus for offline mode, we need to plan accordingly.

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Empowering Engineering students through employability skills

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Abstract: "Skill growth is critical in stimulating a sustainable development environment and will help to ease the transition from an informal to a formal economy," according to the International Labour Organization. In the light of globalization, it is also important to discuss the possibilities and pressures of meeting emerging demands from changing economies and modern technologies."

Management and innovation students who want to be practitioners require not only soft skills but analytical and datum, to achieve the organization's objectives.

The Indian manufacturing sector is revered globally and is one of India's most successful industries. It has made a significant contribution to India's capital formation and hence GDP. Over the years, global expertise and enabling sale situations have ensured that India continues to be one of the world's most commercial healthcare and manufacturing markets. The job process has seen a notable shift; technology affects customs and skills, and communities are becoming more global and diverse. As an effect of globalization, education systems are now also looking at the employability market. Apart from technical skills, applicants are also expected to have interpersonal skills in the current scenario. The study aimed to determine final-year engineering learners' perspectives, faculty-approved by engineering colleges and technical specialists from various professional bodies on training needs, career progression, and career apprenticeship programs.

Keywords: Career progression; Employability skills; interpersonal skills.

JEET Category—Research

1. Introduction

Around 6.35 lakh candidates take the all-India entrance test for the 19 Indian Institutes of Technology, 31 National Institutes of Technology, 18 Indian Institutes of Information Technology, as well as other technical institutes last year in India. Students should be prepared to enter the job market after completing a four-year degree program. However, students' distress and failure to find work have been exacerbated by aspirations from global corporations and increased rivalry. They must study

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administer numerous technical and non-technical jobs in a multidiscipline context, in addition to their competence. Fundamentally, the function of the engineer and industry expectations has widened and technical knowledge and skills must be altered to match these demands.

Employability is internationally impacted by the restructuring of higher education and a major industrial recession. In India, one of the primary concerns of rising unemployment among technology students is the increasing number of educational institutions offering engineering education. [1] The main aim of every engineering college is to provide competencies and characteristics. The basic goal of every engineering institution is to have the expertise to assist students in their employability and entrepreneurialism. It is the dream of every engineering graduate to get a good job after completing the degree. Nowadays, educational institutions are facing the challenge of developing the employability skills of students. Even in a dilemma to consider an acceptable solution that may have more career development approaches for students, technical education like pharmaceutical and engineering education does not identify the way and out to improve employability skills? Strong soft skills—the one thing that machines can't replace—are becoming increasingly important as automation and AI continue to reshape whole sectors, businesses, and employment. (Saira 2019).

As a result, Educational Institutes should concentrate on a rigorous education program in the current situation. Some companies employ employees merely based on skills and knowledge pertinent to a specific carrier.

Therefore, educational institutions are genuinely worried about the growth of job opportunities and are introducing the principle of an evaluation of employability to define and plug inequalities from the first year onwards.

2. Review of Literature

Employability is a word trending nowadays. Hillage and Pollard, 1998 refer to Employability as a person's capability of gaining initial employment, maintaining employment, and obtaining new employment if required.[3]

The term "employability" refers to the ability to work. Employability is defined as an individual's ability to find work, keep it, and find new work if necessary. [3] Harvey stated in 2001 about the ability of a graduate to find a fulfilling job is known as employability.[4] Pool and Sewell in 2007 mentioned that employability is having a set of skills, information, understanding, and individual characteristics that make a person more probably to select and secure professions in which they can be satisfied and successful.[5] Lankard in 1990 defined Employability skills as personal image, interpersonal skills, and good habits and attitudes. [6] According to Hillage, Employability is the potential to change self adequately within the industry to understand perspective through sustainable employment. [7]

Nevertheless, it is critical to determine the perspectives of different medical aspirants, including learners, on the competencies necessary for jobs in companies. It is also a strange fact that there are few instructional investigations to learning-based perspectives. [8] Indian learners have a deep commitment for awareness to recognize the employability skills expected by the international job sector. For this cause, the learners can't be criticized, but institutions of higher learning providing higher education would still need to take personal responsibility and redesign the programs at convenient times to meet the industry needs. [9] According to Scott et al study, there is a sense of momentum to understand learners' sensitivity to knowledge and skills to ensure what is being delivered is appropriate. As a result, the objective of this research is to assess how different medicines professionals view the competence disparity across companies and academics.[10] Bansal Ajit (2018) had concluded in his study that to offer world-class education to management students, the institutions of higher education should improve upon their syllabi and introduce innovative, industry-specific teaching pedagogy. [11]

3. Material and Methods

i) Rationale and objectives of the study:

The present research is conducted to ascertain the training needs for employability in the manufacturing sector. The following are objectives of study under question:

1. Interpretation of experts and researchers in the industry of skill deficiencies and boot camps.

2. Interpretation of research and professionals representatives regarding discrepancies that influence the success of learners.

3. Interpretation of academia and business stakeholders on barriers to joining a boot camp.

4. Academics and business practitioners' understanding of the abilities they anticipate from boot camp.

ii) Research Design & Sampling Method:

Study design

A cross-sectional survey was conducted using self-administered questionnaires and Google forms.

Data Collection Tool:

Two questionnaires were prepared for collecting the data from the respondents. The objective of the first questionnaire was to collect information from engineering graduates and postgraduates in the final year. The second questionnaire was aimed at collecting information from teachers employed by engineering colleges and industrial experts with a minimum of 5years of experience. There were 13 multiple choice questions and one open-ended question in the first questionnaire. They concentrated on prospects in the drug companies, assessments of the technical abilities of graduates, and impressions of instruction. The research instrument consisted of nine issues related to the assessment of the creative expertise of learners, the evaluation of the course, and the interpretation of instruction. Inquiries with a seigniorage of item content <0.75 eradicated from the checklist. The value obtained from the material credibility scale 0.93.

iii) Sample Size

The data set was determined using the formula. N = Z al2 x p (1-p)/d2. The data set measured was 325 for students, 100 for university professors, and 75 for experts in the industry. Where Z = normal standard varies (Z = 1.96 when the confidence interval is 95%), P = population outcome ratio (based on pilot study) and d is the accuracy (0.05) [10].

4. Data Analysis

The information collated from the survey method slip has been translated into quantitative coding from symbol coding. Quantitative variables were calculated by using SPPS 20 by descriptive statistics. To find a correlation between categorical variables, a Chi-square test was carried out.

Table 1: Interpretation of experts and researchers in the industry of skill deficiencies and boot camps

No	Concerns	Engg Exp	SA	A	N	DA	SDA	P Val
1	Grads have ample technical competence	Res	4 (4)	19 (19)	11 (11)	58 (58)	8 (8)	
		Exp	7 (9)	28 (37)	16 (21)	13 (17	11 (15)	0
2	Without training, engineering grads may achieve practical knowledge.	Res	3(3)	9(9)	2(2)	60(60)	26 (26)	
		Exp	4(5)	15 (20)	6 (8)	34 (45)	16 (25)	0.04
3	The syllabi of Engg grads are as per ind expect.	Res	2(2)	11 (11)	9 (9)	58 (58)	20 (20)	0.01
		Exp	5(7)	13 (17)	16 (21)	32 (43)	9 (12)	
4	Academe and Industry disparity	Res	55 (55)	33 (33)	2(25)	6(6)	4(4)	0.77
		Exp	22 (29)	42 (56)	5 (7)	4(5)	2(3)	
5	Engg learners require training to achieve their objectives.	Res	48 (48)	37 (37)	6(6)	2(2)	7(7)	0.05
		Exp	25(33)	35(47)	4(5)	7(9)	4(5)	
6	Training raises the level of trust of learners	Res	59(59)	31 (31)	0	3(3)	7(7)	0.7
		Exp	39(52)	31(41)	4(5)	1(1)	0	

5. Results and Discussion

Engineering Student Outcomes

A total of 325 administered survey returns were obtained from respondents. Only those who are involved in participating in this study are given a questionnaire. Most students (67.5%) are conscious of the possibilities in engineering fields, such as mechanical engineering, computer science engineering, electrical and marine engineering, etc.

It is evident from Table No 1 that most of the researchers (88%) and experts (89%) are of the view that there is a great disparity between academia and industry. The Mann- Whitney technique was done to see whether there was a difference of opinion between

the two sides. P=0.765 has been discovered which means the views of both groups are identical. According to the research, there is still a misalignment between the entire curriculum delivered and the profession's expectations.

Although it was fascinating to learn that the majority of respondents believe that additional training programs are needed for undergrads to achieve their goals. Mitashree Tripathy (2017) had find out that engineering learners must have a wide range of employability skills, which renders them more competent and employable. Employability skills, in addition to technical skills, must be taught at engineering schools through theory and practice [12] .

Over 92% of the respondents believed that training will raise the confidence level of learners. Moreover, respondents were of the view that the syllabus of both postgraduates well as graduate programs is not as per industry requirements and needs to be revised.

As per the survey, most of the faculty is of the view that engineering grads lack skills. Misra, R., & Priyadarshini, R. 2018, had concluded that soft skills are very much required for increasing the employability skills of engineering graduates. Hence it is critical that these skills be taught in technical courses so that engineering graduates are well-equipped with both hard and soft skills[13] .

When it came to finding gaps that directly affect student achievement, 64 percent of academics chose a dearth of comprehension and professional skills as a factor. There is no major gap in the perceptions of engineering practitioners, as Seen by p = 0.1866 (Table 2). Numerous studies support the notion that engineering graduates, from even the best schools, are still unable to match industry requirements (e.g., Lakshminarayanan, Kumar, & Ramanakumar, 2014; Radermacher & Walia, 2014) [14] [15].

Singh, D. (2016) had concluded that companies anticipate students to be up to date on the current developments, yet academia is notoriously slow and focuses on the fundamentals of subjects that are frequently outdated. In the first or second year, colleges must fill the gap. Students should be taught foundational skills such as English and reasoning ability in the first or second semester through bridging courses. Regrettably, the awareness and development of these talents (also referred to as employability skills) is often overlooked in favour of the degree or certificate. Until recently, core competencies were a largely unappreciated factor in a person's career. However, it has gradually become recognised that neither merit nor qualification assures success in any field; however, qualities that can be the antidote for a successful career are frequently overlooked [16

Table 2: Interpretation of research and professionals representatives regarding discrepancies that influence the success of learners

No.	Concerns	Engg Experts	Fundamental Proficiency	Applied Compet.	Fund Prof & App comp	P-value
1	Gaps that directly affect fresh grads performance	Exp	6(6)	30(30)	64(64)	0.19
		Res	6(8)	30(40)	39(52)	

It is evident from table no 3 that paucity of time, resources, and money are the major barriers due to which the engineering graduates are not able to join boot camps.

Table3: Interpretation of academia and business stakeholders on barriers to joining a boot

Sno	Concerns	Engg Expert	Paucity of time	Paucity of resources	Paucity of money	All of them	Others	P-value
1	Major barriers to join boot camp	Exp	4 (4)	20 (20)	2 (2)	70 (70)	4 (4)	0.392
		Res	6 (8)	12 (16)	2 (2.67)	53 (71)	2 (3)	

The majority of scholars (79%) said they want instruction to include both generic information and analytical abilities, but a lot of business practitioners (72%) said analytical abilities were more essential There were no differences as indicated by p = 0.054) respondents). Gurumoorthy, T. R., Nachammai, S., & Thangam, A. had found that many obstacles faced internships, including a lack of proper direction and assistance for students throughout the internship, as well as a lack of adequate money. Internships should be planned and carried out as a valuable learning opportunity[17].

Interpretation of technical competence

They may not have sufficient qualifications and characteristics to meet technical competence, according to graduates (47.8 %). The majority of students (53.2%) stated that they lack both fundamental proficiency and applied competency (readiness to implement), as well as a few learners

Table 4: Academics and business practitioners' understanding of the abilities they anticipate from boot camp.

No	Concerns	Engg Experts	Fundamental Proficiency	Applied Compet.	Fund Prof & App comp	P-value
1	Abilities anticipated from boot camp	Exp	1(1)	20(20)	79(79)	0.54
		Res	15(20)	54(72)	6(8)	

(35.6%), believed that practical abilities were the determining factor in everyone's performance.

Interpretation of boot Camps

A total of 53% of students indicated that they were not aware of digital boot camps at all. Any students (31.5%) do not attend any of the classes during their graduate time; educational plans correspond with their career interests.

Table 5: Learners viewpoint

No	Concerns	**Learners viewpoint % (n=325)**
1	Knowledge of services for online instruction	47
2	students who are not attending any boot camp	31.5
3	The paucity of time, money, and other resources are the major barriers to join a boot camp	47.8
4	Proficiencies expected from training	fundamental proficiency + applied competency- 73.6%

Time was the main obstacle to them attending the boot camp according to 21% of them. The number of learners (95.3 percent) agreed that there is still a great need for training. Only 35.9%, nevertheless, favor online rather than offline training services. This is because almost all of them are familiar with digital boot camps. In Table 5, other results are summarized.

The current research's findings are consistent with previous studies by Balakrishnan Athira et al[12], which found that the majority of respondents believe there is a difference across corporate & academics. To summarise, this study uncovered several critical aspects of technology students', educators', and industry practitioners' understanding of technical competencies, whether appropriate training is required or the program needs to be updated to meet industry standards, and also what expertise clients anticipate from learning. An even more main observation of this research was that digital educational services were not favored by students. This may be because only a handful is aware of opportunities for virtual learning. It is also observed that 31.5% of respondents are not attending any boot camp. The paucity of time, money, and other resources are the major reasons for which students are not able to attend the boot camps.

Limitations of the study:

The low feedback of academics and corporate experts to the survey, which could contribute to nonresponsive bias, is the major flaw in this study. The study was done in the context of India only. The surveyed population may not represent the whole universe. The information was taken mainly from Primary Sources.

6. Conclusion

This study concluded that learners require training programs that prioritize realistic dimensions to accomplish their goals, as the application of theoretical principles to practical situations is unclear. The curriculum of training should be it is carried out according to the career interests or choices of students. The incorporation in the curriculum of case studies and simulation laboratories would help to provide practical experience. As a result, we can deduce that obtaining a decent job requires more than a simple degree; instead, learners must keep on developing quality to the resume in the light of general skills nowadays alluded to as employability that will make them more employable by employers in their field.

Conflict of interest:

The writers are not disclosing any conflict of interest. The writers themselves are responsible for the quality of this article and its composition.

Source of Funding

No financial aid or funding has been received from any source for this research.

Ethical clearance

The survey participants were told about the study intent and their consent was obtained before being included in the survey.

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An Effective Way of Teaching Fundamentals of Robotics to Undergraduate Students using RoboAnalyzer

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Abstract: Robots are becoming increasingly important as the world continues to evolve. Robots are needed to achieve higher production rates and competitiveness. Many universities have already started to offer robotics courses in response to the growing demand for automation. However, in a traditional classroom teaching method, students find it challenging to apply pure mathematical algorithms in robotics. The lack of visualization of robot modelling affects the students learning interest. It becomes imperative to introduce simulation software in teaching the fundamental concepts of robotics. This paper presents the application of the RoboAnalyzer tool to teach the robotics course at the undergraduate level. The methodology was adopted to complement the theoretical concepts of robotics. In the present study, we collected feedback from the students about the method. The results show that around 76 % strongly agreed that the RoboAnalyzer tool improved learning efficiency, and 74 % strongly agreed that the combination of conventional teaching and the simulation tool is better than the traditional teaching method. RoboAnalyzer was implemented during the academic year 2019 – 2020 and received a positive response.

Keywords: learning, modelling, RoboAnalyzer, robotics, simulation, undergraduate,

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1. Introduction

The robotics field is generating considerable interest due to the wide variety of applications in health care, manufacturing industries, space, mining, defense, agriculture, etc. Experts have always seen robotics as the leading technology of the fourth industrial revolution. By 2026, the robotics market will reach 74.1 billion US dollars . Robotics courses and minor degree programs are now being offered by universities, engineering, and technical colleges. Robot kinematic model is one of the core topics of serial chain robotics. This includes forward and inverse kinematics, jacobian, singularity analysis, trajectory planning, path planning, etc. These topics are important and required to apply theoretical knowledge to real-world problems of industrial robots. The other part, known as dynamics, deals with the torque or force control. Mathematical knowledge such as linear algebra, calculus, geometry, and mechanics is required to understand the fundamentals of robotics. However, robot technology is very complex. Robot architecture, motion, etc., are difficult to grasp without hands-on experience with

real industrial robots or any supporting tool. For example, Arnay (2017) reported the difficulties faced by the students due to mathematical or geometrical knowledge required to understand the concepts of robotics –.

The issues faced by the teachers and students while teaching and learning robotics compelled researchers to develop an application or toolbox to tackle the hurdle. In the literature, many software packages and toolboxes have been developed to complement concepts of robotics in the past " . Arnay (2017) compared several robot simulation programs developed specifically for the robotics – . Das (1999) developed a software package known as Robot Computer-Aided Analysis and Design (RCAAD) for planetary landers, flight research, and rovers . Similarly, Hill and Tesar (1996) developed a standalone command line-based tool known as Rapid Analysis Manipulator Program (RAMP) to analyze serial robots . However, these software tools were not intended for educational purposes – . Several toolboxes have been developed based on proprietary software such as MATLAB or Mathematica. ARTE, Robotics Toolbox by Peter Corke, Robotica etc., are some of the toolboxes developed for educational purposes. However, these toolboxes require proprietary software packages to work. Some colleges may not have access to such proprietary software packages. Othayoth (2017) reported several PC-based software packages tools such as Robotect, CoppeliaSim, RoKiSim, RoboDK, Webots, etc., (Othayoth et al., 2017). These software's are intended for analysis, simulation incorporated with virtual sensors and actuators, and programming. Some software packages are capable of simulation of mobile robots with the virtual environment, such as CoppeliaSim. Sabnis (2021) reported modelling and simulation of an industrial robot using computer-aided design software (Sabnis et al., 2021). However, this method is time-consuming and requires good knowledge of computer-aided skills (A. L. Talli et al., 2020). RoboAnalyzer is another evolving software tool developed at IIT Delhi for educators, students, and researchers (Gupta et al., 2017; Othayoth et al., 2017). Fig. 1 presents the canvas of software packages and toolboxes developed for robotics. The present landscape is populated with a variety of software packages and toolboxes to fulfill the needs. The present situation demands a simulation tool to build a strong relationship between the students and fundamental concepts of robotics. Gupta (2017) states that the comprehension of robot motion is further enhanced by implementing a visualization tool (Gupta et al., 2017).

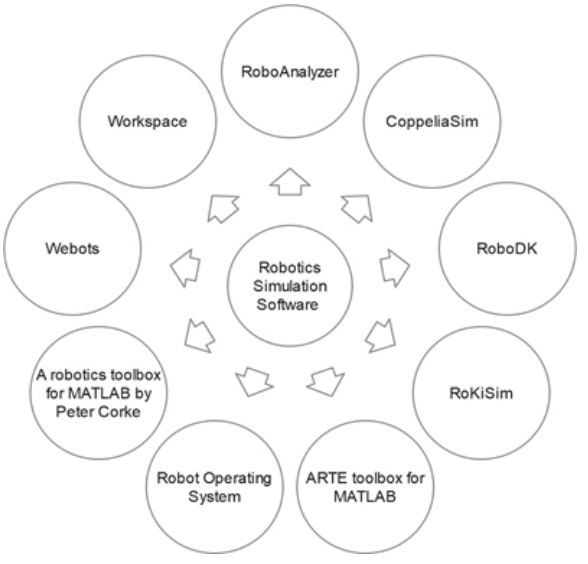


Fig. 1: Robot simulation software

The present paper examines the effectiveness of t eaching fundamentals of robotics using RoboAnalyzer. Our work aims to train and develop the skills of students in the robotics field. We chose this particular approach to complement the theoretical concepts and motivate the students through simulations. The software is implemented to help the undergraduate students to build robot models based on Denavit – Hartenberg (DH) parameters. Furthermore, the students are trained to solve the forward and inverse kinematics problems, visualize the joint movement, etc. Finally, the effectiveness of this approach is collected from the feedback questionnaire or survey. The majority of respondents felt positive and interested to learn robotics concepts.

This paper is divided into five sections. Section 2 provides an overview of the methodology. Section-3 introduces the RoboAnalyzer with few examples. Section-4 describes the evaluation and student feedback. Section 5 presents the conclusion of the paper.

2. Methodology

In the present section, the contents of the robotics course are shown in Table 1. The course duration and credits for the undergraduate program were decided at the university level.

Table 1: Course contents

Chapter No.	Title	Hours
1	Introduction to Robotics and Applications	2
2	Representing Position and Orientation	4
3	Position Analysis of Serial Manipulators	8
4	Jacobian Analysis of Serial Manipulators	6
5	Statics and Dynamics of Serial Manipulators	6
6	Trajectory planning	7
7	Wrist Mechanisms	7
8	Tendon-Driven Manipulators	5
9	Robot End-Effectors	5

The four-credit (4-hours per week) was offered to second-year or fourth-semester undergraduate students. The lesson plan containing the course contents was distributed to the students before the commencement of the semester. Every course content in the lesson plan is equipped with course outcomes (Cos). The course outcomes (COs) of the robotics course are as follows:

1. Explain the design and construction of robots, as well as their wide application (L2)

2. Locate an object's position and orientation in 2-D and 2-D Cartesian space analytically using vectors and matrices (L2)

3. Develop the Homogeneous transformation matrix by using Denavit–Hartenberg parameters for serial manipulators (L3)

4. Generate a trajectory planning for smooth robot motion by using polynomials. (L3)

5. Describe the working principle of the wrist mechanism and draw the kinematic diagram of the wrist mechanism(L2)

6. Perform Kinematic & Static analysis of Tendon – Driven mechanism (L3)

3. Design and select robot end-effector to perform a specific task (L3)

Each course outcome is assigned with the knowledge level as per Bloom's taxonomy level, e.g., L1 - Knowledge, L2 - Understand, and L3 - Apply. Furthermore, the course outcomes (COs) are mapped with the program outcomes (POs).

The program outcomes (POs) of a specific program or department are aligned with the graduate attributes (GAs) recommended by the National Board of Accreditation (NBA). Fig. 2 shows the graduate attributes (GAs).

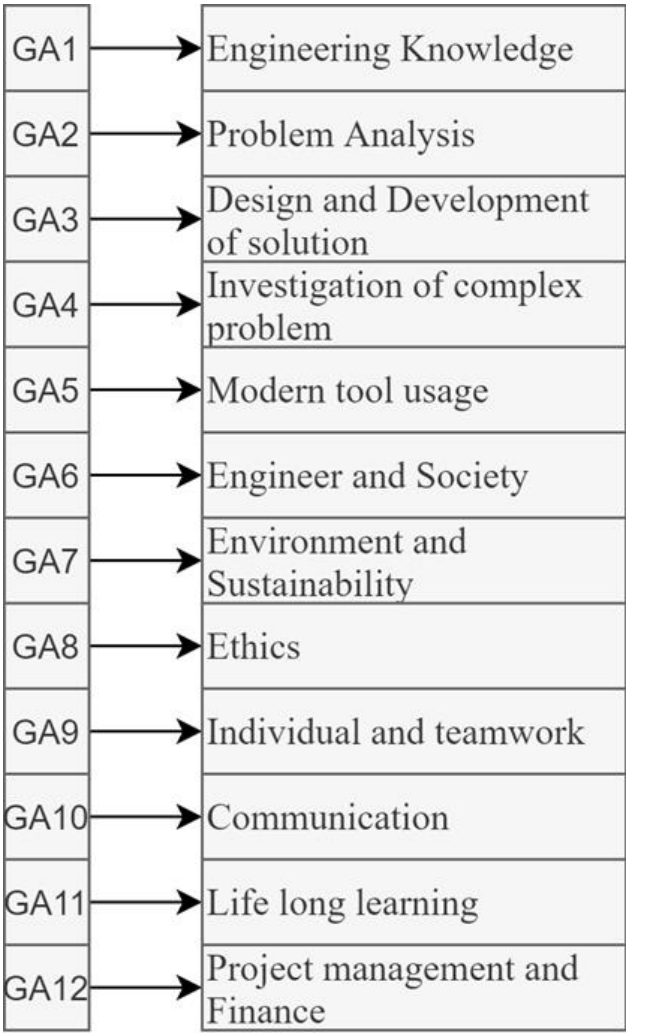


Fig. 2.: Graduate Attributes (GAs)

NBA has established specific parameters known as Graduate Attributes (GAs) for the engineering programs. Outcome-Based Education (OBE) enables transformation in curriculum, new practices in education to enhance learning and engineering graduate skills. This brings a positive attitude in teaching and assessment methods in academics (Bhagyalakshmi et al., 2015). The respective departments align their program outcomes (POs) with the graduate attributes (GAs). Furthermore, the applicable program outcomes (POs) are then mapped with the course outcomes (COs). The GA-PO-CO mapping is shown in Fig. 3.

Table 2 : Course Outcomes - Program Outcomes Mapping

COs\POs	a	b	c	d	e	f	g	h	i	j	k	l
1		M										
2		M	H									
3		M	H	M		H					M	
4		M	H	M		H					M	
5		M										
6		M	M									
7		M	M									

Where, L: Low, M: Medium, H: High

Table 2 presents the course articulation matrix: Mapping of Course Outcomes (CO's) with Program Outcomes (Pos).

Several authors have highlighted the problems faced by the students while studying the concepts of robotics, such as kinematics, transformation, geometry, and perception of robot motion (Arnay, Andez-aceituno, et al., 2017; Othayoth et al., 2017; Zhou et al., 2020). We selected some contents such as robot modelling, transformations, forward and inverse kinematics, etc., which require mathematical and geometrical skills at the initial stage. These contents were used to teach along with the RoboAnalyzer. The RoboAnalyzer was selected due to its standalone features, minimal resources, and visualization. It can be downloaded directly from the website, http://www.roboanalyzer.com/.

A. Forward and Inverse Kinematics

Forward and inverse kinematics are the two important concepts dealt with in serial chain robotics. The position of an end-effector for the specified joint values is determined by forward kinematics. Conversely, inverse kinematics determines the joint values for the specified position of an end-effector (A. Talli & Marebal, 2021b).

1) Forward Kinematics

Denavit – Hartenberg (D-H) method is used in robot kinematics (Ha, 2008). The D-H method uses screw theory to show the transformation of coordinate frames (Denavit & Hartenberg, 1955). The D – H method is the de-facto standard for describing the robot's entire architecture (A. Talli & Marebal, 2021a). The students must read and understand the D-H parameters of various robots. Table 3 shows the D-H parameters.

Students were encouraged to draw a rough sketch

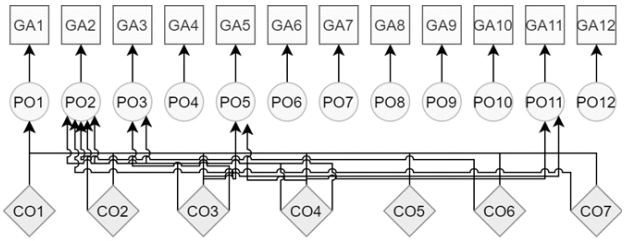


Fig. 3 : GA-PO-CO Mapping

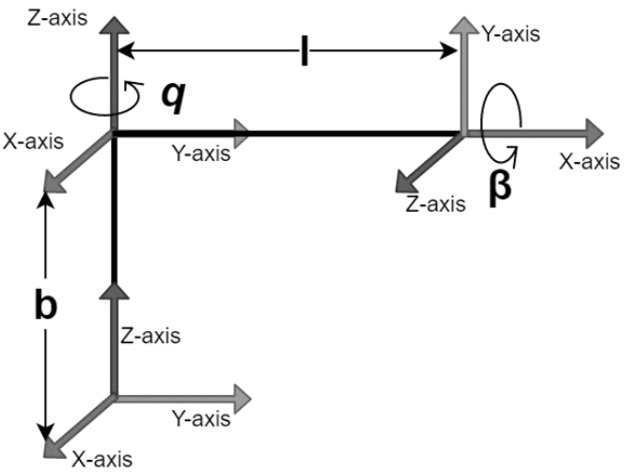


Fig. 4 : Denavit-Harternberg parameters

Table 3. d-h parameters

Parameters	Symbol	Description
Link Offset	b	The displacement along the z-axis
Joint Angle	q	The angular displacement about the z-axis
Length of link	l	The displacement along the x-axis
Twist Angle	β	The angular displacement about the x-axis

of a robot from D-H parameters to attach coordinate frames is shown in Fig. 4. Table 3 shows the four parameters for describing the robot structure. The joint parameters are considered variables, and link parameters are considered constants. The joint type could be revolute or prismatic, depending upon the robot's configuration. The other two parameters define the link length and twist angle.

The robot kinematics involves the multiplication of 4 X 4-dimensional matrices. The resultant general transformation matrix is obtained from Table 3. Equation (1) represents the 4 X 4 transformation matrix is as follows:

$$T = \begin{bmatrix} cos(q) & -sin(q)cos(\beta) & sin(q)cos(\beta) & acos(q) \\ sin(q) & cos(q)cos(\beta) & -cos(q)cos(\beta) & asin(q) \\ 0 & sin(\beta) & cos(\beta) & b \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1)$$

Equation (1) is also referred to as a homogeneous transformation matrix. The mathematical complexity of transformation increases as the mobility or degrees of freedom increases. As reported earlier, mathematical and geometrical operations are troublesome for the students. Furthermore, the difficulty level also increases as the robot configuration becomes complicated. For six degrees of freedom robot manipulator, the pose of the end-effector is determined by the following equation:

$$^{\text{Base}}T_{\text{End-effector}} = {}^{0}T_{1} * {}^{1}T_{2} * {}^{2}T_{3} * {}^{3}T_{4} * {}^{4}T_{5} * {}^{5}T_{6} \qquad (2)$$

Base TEnd-effector, shows the pose of end-effector with respect to the foundation or base. For the sake of simplicity, the Eqn. (2) is written in compact form. The chain of transformation matrix yields a four-dimensional transformation matrix consisting of rotational and positional elements.

2) Inverse Kinematics

Inverse kinematics is used to obtain the joint values for the specified position (Kucuk & Bingul, 2010). The inverse of transformation yields multiple solutions to a specific position. Inverse kinematics is complicated as compared to forward kinematics (Sadanand et al., 2016). It consists of non – linear equations, and it becomes difficult for the students to solve and perceive simultaneously. The steps followed in inverse kinematics are shown in the following equations. Equation (1) is rewritten to obtain the following equation:

$$[{}^{0}T_{1}]^{-1} * {}^{\text{Base}}T_{\text{End-effector}} = [{}^{0}T_{1}]^{-1} * {}^{0}T_{1} * {}^{1}T_{2} * {}^{2}T_{3} * {}^{3}T_{4} * {}^{4}T_{5} * {}^{5}T_{6} \qquad (3)$$

Where $[{}^{0}T_{1}]^{-1} * {}^{0}T_{1} = I$ (Identity matrix) and the Eq.(3) is written in simplified form:

$$[{}^{0}T_{1}]^{-1} * {}^{\text{Base}}T_{\text{End-effector}} = {}^{1}T_{2} * {}^{2}T_{3} * {}^{3}T_{4} * {}^{4}T_{5} * {}^{5}T_{6} \qquad (4)$$

Eqn. (4) is further simplified to yield the value of the first joint.

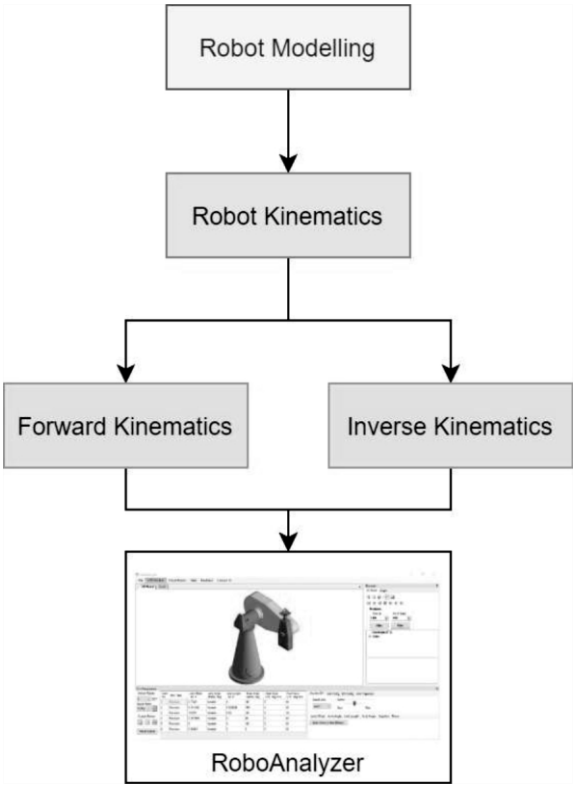


Fig. 5 : Process of robot kinematics using RoboAnalyzer

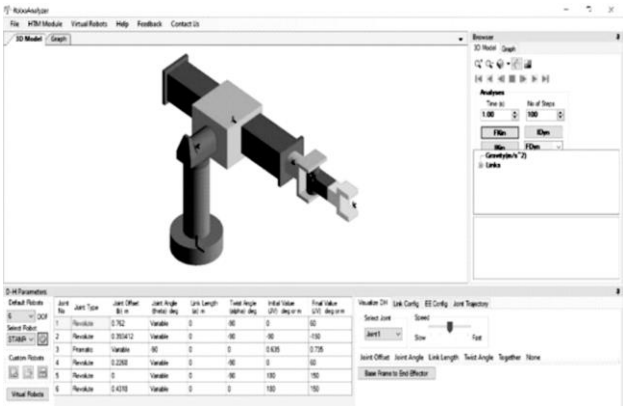


Fig. 4 : RoboAnalyzer interface

Similarly, the other values can be obtained by inverting the equations.

3. Roboanalyzer

This section discusses the process of robot modelling using RoboAnalyzer. Fig. 5 presents the

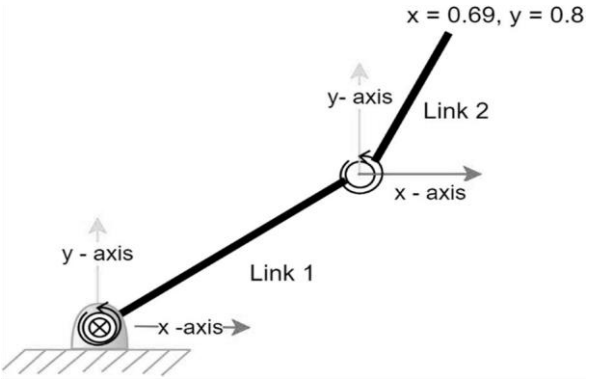


Fig. 6: Line diagram of 2- DoF planar robot

process followed for the robot modelling. As stated in the methodology, the two approaches involved in robot kinematics are forward and inverse kinematics. Teaching and learning the robot kinematics solely based on textbooks is quite challenging due to limited access to the actual or real industrial robots. It is challenging to visualize the concepts of robotics without any aid of software tool (Sadanand et al., 2016).

In the first step of the process, the robot models are built based on DH parameters in RoboAnalyzer. Then, the initial and final joint values are specified to simulate a robot. After these steps have been carried out, forward and inverse kinematics results are obtained. Furthermore, the results obtained from the analytical derivations are verified using the Robo Analyzer for validation. This method complements the course and motivates the students.

A. A Few Examples

The present section provides a step-by-step solution of a set of examples using RoboAnalyzer. Initially, the students are asked to draw a line diagram of a simple two degrees of freedom (DoF) planar robot from D-H parameters, as shown in Table 4.

Table 4 : d-h parameters of 2-dof planar robot

Link	q	b	l	.
1	q_1	0	0.8	0
2	q_2	0	0.4	0

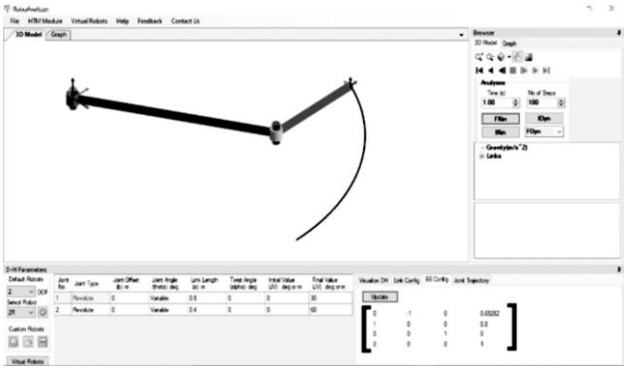


Fig. 7 : Modelling of 2- DoF planar robot in RoboAnalyzer

As shown in Table 4, four parameters are used as Joint variable (q), Link offset (b), link length (l), and Twist angle (β). The unit for joint variable and twist angle is described in 'degree or radians', and link offset and link length is described in 'meter'. The line diagram of the two – degrees of freedom (DoF) planar robot is shown in Fig. 6.

After drawing the line diagram of the planar robot, the students are guided towards developing kinematic equations analytically. The forward kinematic equations are developed by using the D-H parameters. Kinematic equations are derived using the chain of the homogeneous transformation matrix (A. Talli & Giriyapur, 2021).

Base TEnd-effector = Trans(q1) * Trans(b1) * Trans(l1) * Trans(β1) * Trans(q2) * Trans(b2) * Trans(l2) * Trans(β2) (5)

Equation (5) represents the compact format of the 4 X 4 homogeneous transformation equation, and the subscript represents the parameters associated with the link number, simplification of Eqn. (5) yields Eqn. (6) and (7)

$$X = 0.4\,C12 + 0.8\,C1 \quad (6)$$

$$Y = 0.4\,S12 + 0.8\,S1 \quad (7)$$

Equation (6) and (7) represents the position of two – degrees of freedom planar robot. For the sake of simplicity, Cos (q1 + q2) = C12 and Sin (q1 + q2) = S12.

The developed forward kinematic equations are validated using RoboAnalyzer. By substituting joint variables, q1 = 30o and q2 = 60o in Eqn. (6) and (7) yields:

X = 0.692 m and Y = 0.8 m

After obtaining the analytical results, the students are asked to build the same model in RoboAnalyzer.

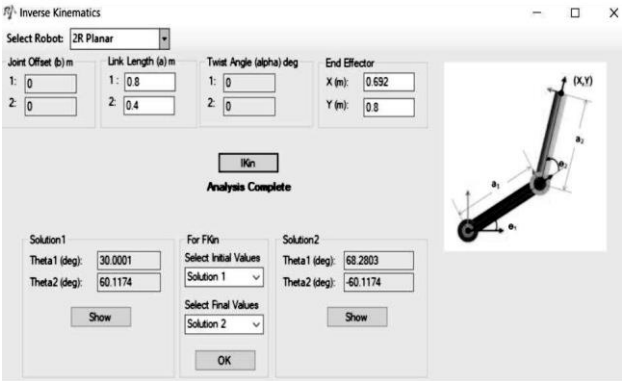


Fig. 10: Inverse kinematics of 2 – DoF planar robot

Fig. 7 shows the 2- DoF planar robot built using RoboAnalyzer.The position values of the 2- DoF planar robot for specified joint values in RoboAnalyzer are shown in Fig. 8.

The position values for the specified joint values are then compared with the analytically obtained values for consistency.

Similarly, the inverse kinematic equations are derived for the two links planar robot, and the joint values are determined for the known configuration of the robot. The inverse kinematics is activated by clicking the "IKin" option, as shown in Fig. 9.

The inverse kinematic equations are obtained by adding and squaring Eqn (6) and (7). Inverse kinematics is not easy compared to forward kinematics due to highly non-linear trigonometric functions (Othayoth et al., 2017). The developed inverse kinematic equations are cross-checked with the same position values analytically. Furthermore, the equations are also validated using the inverse kinematic module of RoboAnalyzer. The 2- link planar robot is selected from the dropdown menu to specify link length position in the X and Y direction, shown in Fig. 10. The RoboAnalyzer also performs



Fig. 11:Possible solutions of inverse kinematics of 2 –DoF planar robot



Fig.12 : Kuka KR5 Arc robot (6 – DoF) in RoboAnalyzer

inverse kinematic analysis for six degrees of freedom robot manipulator. The inverse kinematics yields up to eight solutions for the robot's specific configuration. Similarly, more complex problems can be visualized by using RoboAnalyzer. The robots such as 2R, 2P, RP, PR,3R, RRP,3R Articulated, Wrist, PPPRR, MTAB Mini, 6R Decoupled Manipulator, Kuka KR5 Arc, MTAB Aristo, SmallArm, and 6R Generic Manipulator are available for the inverse kinematics.

Fig. 11 shows the two possible solutions for the inverse kinematics.

B. Virtual Robot Module

This section presents the other features and examples of RobAnalyzer used for teaching robotics. Fig. 12 shows the RoboAnalyzer interface with six-

Table 5 : robot models in roboanalyzer

Degrees of Freedom	Robot Model
1	1P and 1R

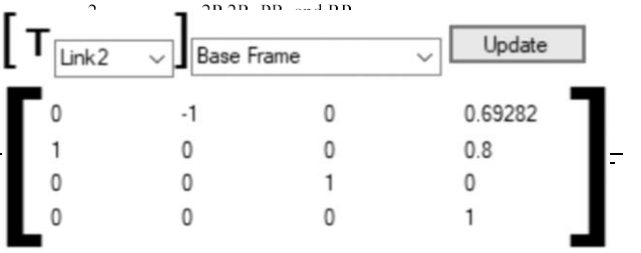


Fig. 8. Position values in RoboAnalyzer

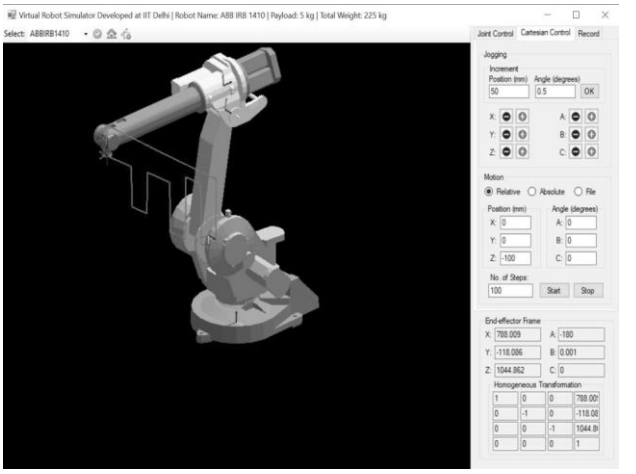


Fig. 9: Analyses option in RoboAnalyzer

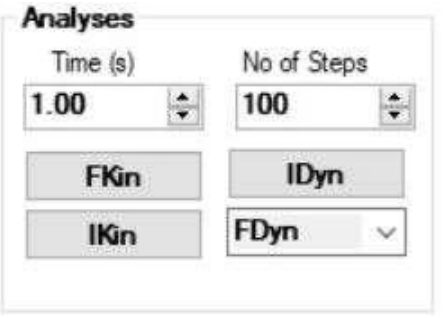


Fig. 9: Analyses option in RoboAnalyzer

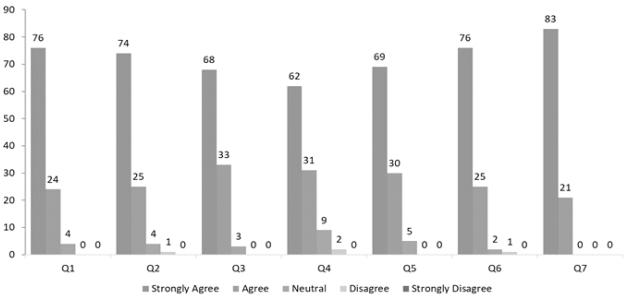


Fig. 14 : Student feedback

degrees of freedom industrial robots performing simulation—other robots such as KUKA KR5 Arc, PUMA, STANFORD, ARISTO, etc., are available to explore. Furthermore, the robots are also classified under degrees of freedom in RoboAnalyzer is shown in Table 5.

The RoboAnalyzer also comes with the Virtual Robot Module (VRM), enabling students to visualize joint and cartesian control. In the joint control tab, a user can jog the joints within the specified range, and the position of the end-effector instantly updates the contents of the transformation matrix (Othayoth et al., 2017). The users can also trace the end-effector path in RoboAnalyzer, which helps to correlate the path traveled as per the joint motion. Under Cartesian control, the students can draw the welding profile using a virtual robot from the available robot model available from the dropdown menu. The jogging control consists of jogging in x,y, and z-direction and angle in A, B, and C for controlling rotational motion. The jogging can be controlled incremental fashion with a smaller resolution. Fig. 13 shows the path performed by using the cartesian control tab. The path can be exported to an excel sheet that contains the data regarding the path. The students could generate different paths, such as welding paths, and record the path as well.

4. Evaluation And Student Feedback

The present section discusses the reaction of undergraduate students. To conclude the robotics course, the students were asked to select an industrial robot to perform the kinematic analysis for the course project. The students were asked to acquire the D-H parameters of the selected robot from the manufacturer catalog or through references. The students should build the robot model in RoboAnalyzer based on D-H parameters. The students should enter all the D-H parameters in the RoboAnalyzer for forward and inverse kinematic analysis.

This type of exercise/project trains them to visualize the D-H parameters and joint motion. Furthermore, students were asked to prepare a report on the robot modelling performed using the RoboAnalyzer.

In order to validate the proposed method, opinion surveys were conducted with undergraduate students. The opinion surveys were conducted using an electronic form such as Google forms. The electronic form consisted of seven statements are shown in Table 6. The electronic form was based on a five-point Likert scale satisfaction questionnaire (A Technique for the Measurement of Attitudes. - PsycNET, n.d.). This method was used to evaluate the presented application of RoboAnalyzer and improve if needed for the next semester. Table 6 presents the statements or questions, along with the five-point Likert scale statements (point-1 stands for strongly disagree, point-2 stands for disagree, point – 3 stands for neutral, point – 4 stands for agree, and point-5 stands for 5-strongly agree) (A Technique for the Measurement of Attitudes. - PsycNET, n.d.). Fig. 14 presents the feedback survey results undertaken to analyze the teaching method implemented for the robotics course. The feedback questionnaire was sent to 104 students undergone the course.

Table 6 : Statements sent to undergraduate students

No.	Questions/Statements
1	The application of the RoboAnalyzer simulation tool improves learning efficiency.
2	Combining theoretical concepts with simulation tools complements the robotics course.
3	I can interpret Denavit - Hartenberg parameters.
4	Solving inverse kinematics is easier.
5	The teaching method has strengthened my knowledge regarding robot kinematics.
6	The same approach can be used in other areas of the robotics course.
7	I am interested in robotics.

The replies for statement 1 (Table 6 and Fig. 14) indicated that the application of the RoboAnalyzer tool received a positive response, with ratings of 4 or 5 given in 96.15 % of the replies, on average. Statements 2 and 3 (Table 6) concern the view of the students to the implementation of a simulation tool in learning theoretical concepts and comprehension of robot kinematics, such as building a robot using Denavit- Hartenberg parameters. In this case, ratings of 4 or 5 were obtained in 95 % of the replies, on average. Statement 5 and 6 received ratings of 4 or 5 were given in 95.1 % and 97.1 % of the replies, on average. In response to statement 7 (Table 6 and Fig. 14), nearly 83% of the responses strongly agreed that they are interested in robotics. However, a slightly lesser agreement regarding statement 4 was noticed regarding the inverse kinematics. In this case, ratings of 5 were given only 68 % of the responses, respectively. The authors would like to consider this viewpoint and improve the method towards inverse kinematics.

5. Conclusion

This article describes a method adopted for teaching robot kinematics to undergraduate students. The feedback survey conducted with undergraduate students of the 2019 – 2020 academic year was encouraging and provided helpful information related to the methodology. The methodology consisted of delivering fundamentals of robot kinematics using RoboAnalyzer. This method was adopted to increase the interest, ease of visualization of the theoretical concept. The students are also encouraged and motivated to learn robotics using different software tools. The present work has only implemented the RoboAnalyzer tool for the robot kinematics portion at present. The methodology's effectiveness was measured based on a feedback questionnaire. The results reflect the feelings of students about the robot kinematics along with the RoboAnalyzer tool. We have found that the students accepted the implementation of RoboAnalyzer tool in learning fundamental concepts of robots. However, the results also show that inverse kinematics remains a challenging concept to understand. Furthermore, students also agreed to implement such simulation tools in other areas of robotics. The authors will use the feedback to explore new teaching approaches and tools in robotics.

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Facilitating Learner Centric Decision Making for Massive Open Online Courses

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Abstract : Learners opt for MOOCs as it provides multiple benefits and the most important being that these courses can be accessed anytime and from anywhere with internet access. Learners can study their desired course at their convenience of time and desired pace. But as there are multiple options for them, they may get confused about selecting a course. This study highlights the findings of implementing the Analytical Hierarchical Process (AHP), a Multiple Criteria Decision Making (MCDM) technique used to choose the best option in case of multiple alternatives. Attributes were selected from literature and a survey was administered to learners. Responses were analyzed and courses were ranked based on their scores. From the analysis, we interpret that usefulness of the course in the University Curriculum is the most preferred criteria while selecting the course.

Keywords : MOOC, Multiple Criteria Decision Making, Analytical Hierarchical Process

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1. Introduction

In our evolving world, technology has taken over multiple domains where it wasn't used back in time. This helps in creating a better working environment which also serves multiple benefits. Education was initially limited to classrooms but now its boundaries have expanded to a whole new level. Everyone cannot travel to a different place to study but the study material can travel to them.

To overcome such issues, Massive Open Online Courses (MOOCs) are introduced. MOOCs are mostly free of charge, which help learners to study different courses and attain certifications that they can use in their professional life(Sachdeva et al., 2016).

This helps learners to remotely access the courses and learn from top educators which otherwise is physically impossible. Some of the key benefits of MOOCs are that courses from different domains are available, timings are completely flexible, and they know how much time will be required for a course to complete (Lucy Bodenham, 2019). Some of the leading MOOC providers are Coursera, edX, and Udacity.

The government is also helping the education sector by setting up various schemes, NPTEL being one of them which was founded by the Ministry of Human Research and Development (Government of India) in

2003. The aim of establishing this was to expand the offering of MOOCs. These courses are run by top institutions like the Indian Institute of Technology which ensures that the learners are getting quality education from trustworthy sources. Certification of these courses is widely accepted by different companies so learners also have an advantage while applying for jobs(Singh et al., 2014).

The objective of this study to determine the criteria which are preferred by learners while opting for a lab-based MOOC and design an AHP to rank the courses so that they can choose the best course from options that are available to them.

This paper consists of VIII sections, Section I is the introduction. Further, Section II describes the AHP technique which we have implemented in this research paper. Section III and IV talks about the benefits and challenges of MOOCs respectively. In section V, we have reviewed the literature which was available on various repositories. Section VI consists of the methodology of how our research instrument was created. Different criteria are also explained in this section. All the calculations and analysis are shown in section VII which is followed by the conclusion in section VIII.

2. Ahp Technique

When we are choosing something, we look for all its alternatives and it is also considered good if have multiple options. But having multiple options is also a problem as it creates confusion in deciding which the best option is. These problems are called Multiple Criteria Decision Making (MCDM) and to solve these Analytical Hierarchical Process (AHP) is one of the popular techniques.

Thomas L. Saaty proposed this decision-making approach termed AHP through one of his works(Saaty, 1984). It divides a problem into many criteria and then calculates priority in each to make a decision. In the paper, he also gave two examples showing the use of AHP as a measure to make the decision. The technique helps in scenarios where we have to make a decision involving multiple alternatives. In AHP decisions are made by creating a hierarchical structure with all the available options(Gandhi et al., 2016). In the hierarchical structure, level 1 is the goal that has to be achieved. Below it, level 2 consists of the criteria which are being considered in the decision making. Level 3 has the alternatives, which are available to us.

AHP works by dividing any problem into multiple subproblems based on the criteria involved and then priority is calculated in each criterion for the alternatives. This helps in ranking alternatives using a logical approach and make a decision.

The AHP matrix is calculated based on preferences of the individual between two criteria which is in turn used to calculate the criteria weights which give us the rankings for alternatives in each criterion as well as the most prioritized criteria. These Criteria weights from each category and criteria weights for all the criteria are used to rank the alternatives and make a decision.

We need to verify if the AHP is consistent by calculating its consistency ratio (CR) which needs to be less than 0.10 for AHP to be consistent, if CR>0.10 we need to revisit our comparison matrix.

3. Benefits

As MOOCs are easily accessible to everyone and learners can study at their own pace, this makes MOOC a very good way to gain new skills. MOOCs also have many other benefits and some of them are discussed below:

A. Round-the-clock availability- Learners can access their course material whenever they are free and are not bound to log in at the time of the lecture. This permits them to focus on other things as well.

B. Diverse options- Sometimes learners are pursuing a degree but want to study another subject that is not part of their curriculum. To match their need, MOOCs are available irrespective of the major/specialization of the learner. They have a large pool of courses to choose from which match their interests.

C. Top-quality content- Learners can choose courses that are curated by professors of top institutions around the world. This provides the opportunity to attain knowledge from teachers whose classes might not be possible to attend by physically going to their universities.

D. An advantage in professional life- Some courses can be done to get better knowledge about some topics

which may be useful in the current job. This will also help them to get raise in their salary and gain more recognition among their colleagues.

4. Challenges

MOOCs have many benefits but they also come with some challenges which are faced by their learners. Some of them are discussed below.

A. No live questioning- Courses are generally prerecorded for learners so the teacher is not present during the lecture. This forbids learners to get their doubts cleared at that time, they have to wait for a QnA session where their doubts can be cleared.

B. Language barrier- Courses are in the English language. Learners from non-English speaking regions will not be able to understand the course.

C. Internet availability- To stream course videos, high-speed internet is necessary. This could be a problem for learners living in remote areas where they don't have proper internet speed.

D. Online payment- Course/Certification fee has to be paid online. There can be some learners which do not have the facility to do online transactions.

E. Credits transfer- In some cases, credits of a MOOC can be transferred to a current college degree, but most of the time colleges do not transfer these credits.

5. Literature Review

We accessed different repositories such as IEEE, ACM, and Taylor & Francis to review the literature. Few papers were also extracted from Scopus which is the citation database of peer-reviewed literature.

Some of the literature which we reviewed for MOOC is as follows:

Oriol Borrás Gené et al. discussed how MOOCs can be benefited by gamification. Gamification is a technique to create an experience similar to games. By doing this in MOOC, learners may be willing to participate more actively as they will experience something new. Their study material was divided into different "missions" which they had to complete for course completion. "Ranking rating" was calculated by the scores of each module and a leaderboard was generated which helped them to compete with other learners. "Number of likes" was also used in which learners could share their course progress or leaderboard score on social media, where their friends will see it and more learners will be engaged (Gené et al., 2014).

Di Chen et al. reported the seriousness of learners towards MOOCs. They found that the completion rate for a course is lower than 10% on average. Reasons for abandoning courses are numerous like the learner may not know what the difficulty level of course was, they started as it seemed interesting but it turned out to be a boring course, there were many assignments so they didn't have enough time for completing. Learners are also enrolled in universities and a certificate obtained by a MOOC is less valuable than a regular course from university so the learners focus more on their university studies as compared to the online course. For analysis, a course from Coursera was taken named "Traditional Chinese Medicine and Chinese Culture". It was found that some of the learners submit their assignments 1-2 days before the deadline but many of them submit after the deadline due to which their grades got affected. The study found out that learners did not give priority to assignments that's why they were submitting them after the deadline (Chen et al., 2014).

To check the influence of immediate feedback on a question in an exam, John W. Harrold, Jr, and Jessica Sandland experimented on a MOOC which was offered by MIT. In that course, there were three tests. While attempting them when the learner entered their answer, they were immediately able to see if it is correct or not. They were also allowed to change their answers a total of 20 times during one exam. As an experiment, this immediate feedback method was removed from the 3rd exam to see how learners reacted to it. It was found that most of them were reluctant in giving the exam after it was revamped. Providing immediate feedback encouraged learners to give that exam and the scores were also high when they were shown immediate feedback. It was also believed that if they were told the correct answer when they selected the wrong one, chances are higher that they will remember this in the future(Harrold & Sandland, 2018).

Prashast Kumar Singh reviewed various MOOC platforms such as EdX, Coursera, Udacity. These are international platforms that are quite popular among learners. India has also launched a MOOC platform

which is named National Program on Technology Enhanced Learning (NPTEL). This is developed with the guidance of the Ministry of Education, formerly the Ministry of Human Resource Development. The courses in NPTEL are controlled and run by different IITs. NPTEL is emerging as learners are getting quality content from highly qualified teachers so they also suggest their fellow learners opt for some courses on the NPTEL platform. Due to its higher quality of study material, this platform is also gaining popularity in the rest of the world(Singh et al., 2014).

We also reviewed the literature to find the application areas of the AHP technique.

Melvin Alexander explained in his paper how AHP was used to find the best suitable phone for his family. He used AHP to find the priority of the attributes and alternatives in each criterion and they were then weighted to find the most preferred smartphone (Alexander, 2012).

Hospitals are a part of essential services and it can be a difficult task to choose between multiple hospitals. They may be providing different services in terms of treatment given, room charges, medicine availability, imaging services, financial aid, etc. To show how to decide, Chosy Yuda Sakti et al. implemented AHP with MOORA to rank multiple hospitals. These methods are used for deciding between multiple options which are available to us. Their qualities are compared with their alternates and calculations are done which leads us to rankings between all the alternates and then the person can decide which alternate they should consider (Chosy Yuda Sakti et al., 2019).

Mohammed Said Obeidat researched in Jordan with Tarek Qasim & Aseel Khanfar to implement AHP for buying a residential apartment. Choosing a home for any individual is very important because once they have bought it, they will be residing in it for a long time as it is not possible to change it frequently. They are investing a significant amount of money in buying so they will thoroughly look at all the options available to them. In this, the researchers took the opinions of builders or land developers, and also the customers who will be investing in these projects. To know their answers, a survey was created with attributes that were checked while buying a house like building age, sewage, electricity, method of payment, price. All the answers were then correlated with the available options and the customers were shown which apartments or houses suit their needs. This helped them not to waste time by going to multiple places where they may be not interested (Obeidat et al., 2018).

Emel Kuruoglu et al. conducted a study in Turkey to evaluate the implementation of AHP which is used by people while choosing a family physician. They gave 96 patients an AHP survey and then created an AHP model to determine what criteria are most prioritized while choosing a family Physician (Kuruoglu et al., 2015).

Though it has been widely used from electronics to healthcare, there are limited studies that focus on the use of this well-established technique in selecting appropriate alternatives in the Education domain.

6.. Methodology

A survey was formed on google forms to gather the responses from learners for the attributes which they check while considering a MOOC. We selected 6 attributes as criteria for the survey.

Table 1 : Selected Criteria

S.No.	Criteria
1.	Platform
2.	Course/ Certification Fee
3.	Offering Institution
4.	Course Content
5.	Instructor Profile
6.	Usefulness in University Curriculum

A pilot test was conducted with 25 participants to ensure the appropriateness of the research instrument. We made some modifications that were needed based on the responses of the pilot study and after that research instrument was broadcasted. A total of 112 learners participated in this study, from which 100 responses were taken for analysis and 12 responses were omitted due to duplicity or incomplete responses. It was mandatory that the participant had opted for any MOOC once so that we will only get responses from learners who have gone through the process of selecting a course.

The participants were asked to answer questions about their preference between different categories and that data was used for creating the AHP

comparison matrix. The survey consisted of 15 questions comparing each criterion against each other and asking the participants to provide their response on the original Scale of 1-9 proposed by Saaty(Saaty, 1984).

While designing the survey we used 6 factors that affect most of the decisions of learners while selecting a MOOC as criteria. The 6 criteria based on which the questionnaire was created are:

A. Platform- This is one of the main factors which learners look for while choosing a MOOC. The choice of platform is important as it affects the credibility of the course which would be more for a well-established platform and less for a new or less known platform(Shrivastava et al., 2019).

B. Course/Certification Fee- This is a major criterion while deciding on a MOOC as a lot of learners are on a budget and a higher price could be the reason to not select a course. Some courses have a course fee which is the price of the course and the learner is required to pay this amount for starting the course whereas certification fee applies to courses that are free to study but the learner has to pay to get a certificate after the completion. Course/Certification Fee is important as the learners look for a course that would give them the best benefit at a minimal cost.

C. Offering Institution- This factor is important while selecting a MOOC as the credibility of the Institution that is offering that course would affect the value of the course, if the course is offered by any reputable organization or university, it would hold more value and be more useful to the learner.

D. Course Content- This is one of the most important criteria while choosing a MOOC as this is the main reason behind doing any MOOC. Course content is the skills or knowledge that the learner would gain from that MOOC and if a course provides better content that is ideally curated to the learners' need it would be preferred by the learner.

E. Instructor Profile- It is also a big factor while considering any MOOC because if the instructor of the course has a good reputation that would increase the value of the course and also the teaching style of the instructor is important as if it is good it would be easier for the learner to learn and more beneficial.

F. Usefulness in University Curriculum- This is a very important criterion while choosing a MOOC as if a course is useful in the university curriculum which means if your current university would provide credit transfer for the course which you choose(Shrivastava et al., 2021). This criterion could affect learners' decisions as if a MOOC can be considered part of the curriculum by their university, it would be helpful for the learners.

AHP hierarchy in fig 1 shows the categories and alternatives for the selection of the best MOOC.

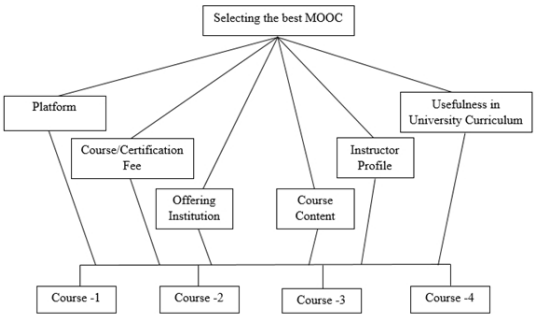


Fig. 1 : AHP Hierarchy

The data collected from the survey is collated and analyzed and then an AHP Comparison Matrix is created. After creating the matrix, the data is normalized using (1):

$$\frac{x}{\sum_{i=1}^{n} x} \qquad (1)$$

Then we use the normalized values in each criterion to calculate the Criteria Weights for all the categories using (2):

$$\frac{\sum_{i=1}^{n} x}{i} \qquad (2)$$

The criteria weight provides us the priorities given to each criterion by learners while choosing a MOOC. After the calculation of criteria weights, we need to verify the AHP using the Consistency Ratio. For Calculation of Consistency Index (CI) we first need to calculate Weighted Sum Value which is calculated using (3):

$$\sum_{i=1}^{n} x \qquad (3)$$

The CI is calculated by using Lambdas which are in turn calculated from Weighted Sum Value and Criteria weights. The lambda max is used to calculate CI as follows:

$$\lambda = \frac{weighted\ sum\ value}{criteria\ weight} \quad (4)$$

$$\lambda_{max} = \frac{\sum_{i=1}^{n} \lambda}{i} \quad (5)$$

$$CI = \frac{\lambda max - n}{n-1} \quad (6)$$

The CI is then divided by Random Index (RI) to find out the Consistency Ratio (CR). RI is given by Saaty in his paper for each number of categories. We have used RI equal to 0.90 when we have 4 courses as criteria and 1.24 when we have 6 criteria(Saaty, 1984).

$$CR = \frac{CI}{RI} \quad (7)$$

During the analysis, we observed that CR for all AHP comparison matrices is less than 0.10 which depicts that they are consistent.

Table 2 : Category Comparison Matrix

	Platform	Certification/Course Fee	Offering Institution	Course Content	Instructor Profile	Usefulness in University Curriculum	Weighted Sum Value	Criteria Weight	
Platform	0.042415243	0.023814385	0.027195506	0.042534419	0.061654084	0.069754331	0.267367968	0.042415243	6.303582138
Certification/Course Fee	0.142212127	0.079846161	0.044843342	0.048854159	0.079742418	0.09960827	0.495106476	0.079846161	6.200754932
Offering Institution	0.189955617	0.216861966	0.1217944	0.054056529	0.08527144	0.111889958	0.779829909	0.1217944	6.402838784
Course Content	0.214021826	0.350775391	0.483566028	0.214623175	0.092152518	0.150773431	1.50591237	0.214623175	7.016541286
Instructor Profile	0.147025959	0.213992499	0.305251377	0.497740887	0.213714461	0.120254073	1.497979256	0.213714461	7.009255473
Usefulness in University Curriculum	0.196195372	0.258640552	0.351215916	0.459292946	0.573419019	0.322654686	2.161418491	0.322654686	6.698859751
								Lambda Max=	6.605305394
								CI=	0.121061079
								CR=	0.097629902

For our alternatives, we chose 4 lab-based courses from three different platforms in the field of web development. All the courses were offered by different institutions such as Universities, organizations, or foundations. All 4 courses were priced in the range of ₹3,500 to ₹4,500. The content for all courses was about 90% similar. All the selected courses were self-paced. Two of the courses had multiple instructors while others had only one instructor, the initials of the instructors are mentioned in table 3. We have assumed that courses from one platform are considered to be valuable in the university curriculum.

The following Courses were used as alternatives for the AHP:

Table 3 : Course Alternatives

	Platform	Certification/Course Fee	Offering Institution	Course Content	Instructor Profile	Usefulness in University Curriculam
Course 1	Platform-A	₹ 3,593	Organisation-X	HTML, CSS, JS	RA, UL	No
Course 2	Platform-B	₹ 4,329	University-X	HTML, CSS, JS, CSS Framworks	YC	Yes
Course 3	Platform-C	₹ 3,589	Foundation-X	HTML, CSS, JS	MH	No
Course 4	Platform-B	₹ 3,595	University-Y	HTML, CSS, JS, Bootstrap	CVL, CRS	Yes

Then, an AHP comparison matrix was created for all courses in each criterion and verified using the Consistency ratio.

Table 4 : Platform AHP Matrix

	Course 1	Course 2	Course 3	Course 4	Weighted Sum Value	Criteria Weight	
Course 1	0.133012821	0.083012821	0.258012821	0.083012821	0.557051282	0.133012821	4.187951807
Course 2	0.665064103	0.415064103	0.331730769	0.415064103	1.826923077	0.415064103	4.401544402
Course 3	0.019001832	0.046118234	0.036858974	0.046118234	0.148097273	0.036858974	4.017943409
Course 4	0.665064103	0.415064103	0.331730769	0.415064103	1.826923077	0.415064103	4.401544402
						Lambda Max=	4.252246005
						CI=	0.084082002
						CR=	0.093424446

Table 5 : Course/Certification fee AHP Matrix

	Course 1	Course 2	Course 3	Course 4	Weighted Sum Value	Criteria Weight	
Course 1	0.3	0.3	0.3	0.3	1.2	0.3	4
Course 2	0.1	0.1	0.1	0.1	0.4	0.1	4
Course 3	0.3	0.3	0.3	0.3	1.2	0.3	4
Course 4	0.3	0.3	0.3	0.3	1.2	0.3	4
						Lambda Max=	4
						CI=	0
						CR=	0

Table 6 : Offering Institution AHP Matrix

	Course 1	Course 2	Course 3	Course 4	Weighted Sum Value	Criteria Weight	
Course 1	0.176004902	0.121838235	0.271593137	0.176004902	0.745441176	0.176004902	4.235343267
Course 2	0.88002451	0.609191176	0.349191176	0.88002451	2.718431373	0.609191176	4.462361698
Course 3	0.025143557	0.067687908	0.03879902	0.025143557	0.156774043	0.03879902	4.040670216
Course 4	0.176004902	0.121838235	0.271593137	0.176004902	0.745441176	0.176004902	4.235343267
						Lambda Max=	4.243429612
						CI=	0.081143204
						CR=	0.090159116

Table 7 : Course Content AHP Matrix

	Course 1	Course 2	Course 3	Course 4	Weighted Sum Value	Criteria Weight	
Course 1	0.096703297	0.083882784	0.096703297	0.110989011	0.388278388	0.096703297	4.015151515
Course 2	0.29010989	0.251648352	0.29010989	0.184981685	1.016849817	0.251648352	4.040756914
Course 3	0.096703297	0.083882784	0.096703297	0.110989011	0.388278388	0.096703297	4.015151515
Course 4	0.483516484	0.754945055	0.483516484	0.554945055	2.276923077	0.554945055	4.102970297
						Lambda Max=	4.04350756
						CI=	0.01450252
						CR=	0.016113911

Table 8 : Instructor Profile AHP Matrix

	Course 1	Course 2	Course 3	Course 4	Weighted Sum Value	Criteria Weight	
Course 1	0.291348358	0.452062643	0.335179526	0.16364273	1.242233257	0.291348358	4.263738665
Course 2	0.097116119	0.150687548	0.201107716	0.16364273	0.612554113	0.150687548	4.065061259
Course 3	0.058269672	0.050229183	0.067035905	0.098185638	0.273720397	0.067035905	4.083190883
Course 4	0.874045073	0.452062643	0.335179526	0.490928189	2.152215432	0.490928189	4.38397199
						Lambda Max=	4.198990699
						CI=	0.066330233
						CR=	0.073700259

Table 9 : Usefulness in University Curriculum AHP Matrix

	Course 1	Course 2	Course 3	Course 4	Weighted Sum Value	Criteria Weight	
Course 1	0.0625	0.0625	0.0625	0.0625	0.25	0.0625	4
Course 2	0.4375	0.4375	0.4375	0.4375	1.75	0.4375	4
Course 3	0.0625	0.0625	0.0625	0.0625	0.25	0.0625	4
Course 4	0.4375	0.4375	0.4375	0.4375	1.75	0.4375	4
						Lambda Max=	4
						CI=	0
						CR=	0

The Criteria Weight from all the AHP matrix is used to create Priorities for each of the courses. The Criteria are assigned Priorities based on their weights as a lower priority for lower weights and higher priority for higher weights. This is represented as a horizontal bar graph in fig 2 shows the priorities assigned to all the criteria by learners while choosing a MOOC, fig 3 shows the priorities assigned by learners to all the courses in their respective criteria.

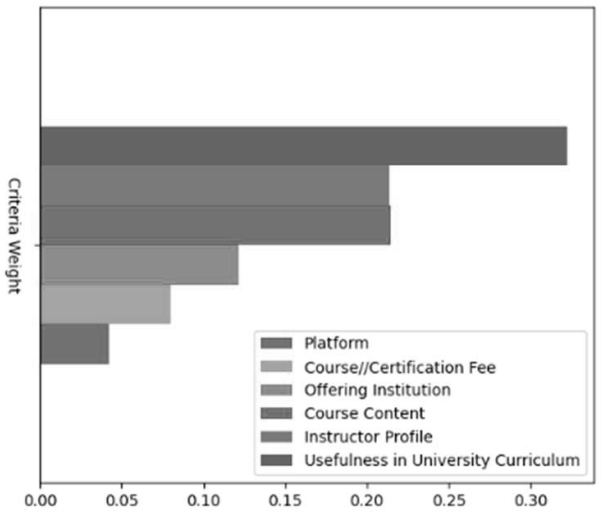


Fig. 2 : Criteria Weight of Attributes

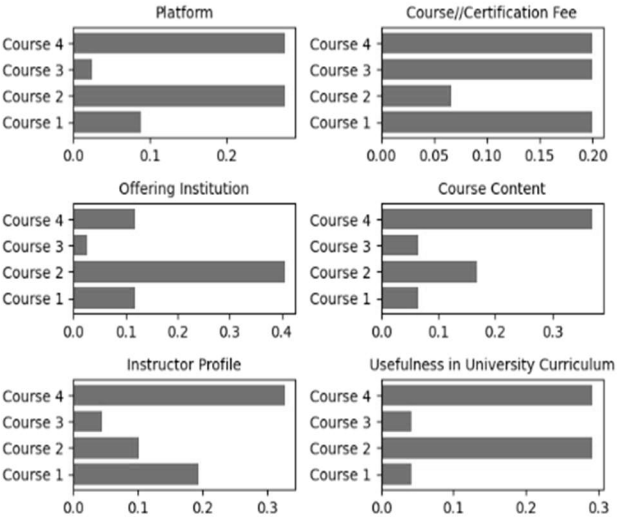


Fig. 3: Criteria Weights of Alternatives in each Attribute

Then, the criteria weights of each course are multiplied to the criteria weight of that category and their sum is calculated which gives us the final critical weight of each course. This critical weight is then used to assign a ranking to each course which is given in the figure below.

Table 10 : Course Ranking

	Platform	Course/Certification Fee	Offering Institution	Course Content	Instructor Profile	Usefulness in University Curriculum	Criteria Weight	Ranks
Course 1	0.005641771	0.023953848	0.021436411	0.020754769	0.062265357	0.020165918	0.154218075	3
Course 2	0.017605045	0.007984616	0.074196074	0.054009568	0.032204108	0.141161425	0.327160836	2
Course 3	0.001563382	0.023953848	0.004725503	0.020754769	0.014326542	0.020165918	0.085489963	4
Course 4	0.017605045	0.023953848	0.021436411	0.11910407	0.104918453	0.141161425	0.428179253	1

8. Conclusion

Many learners are opting for MOOCs now so they must select a course that is good and will be beneficial for them in the future, providing the best opportunities for them. By analyzing the data from the survey we found that learners preferred the criteria "usefulness in university curriculum" the most while "instructor profile" and "course content" were almost equally preferred. The lowest preference was given to "platform" while selecting a MOOC by learners. Furthermore, this data was used to rank 4 MOOCs based on these criteria. After analyzing the data, the courses were ranked based on final critical weight and the data showed that course 4 is ideal as it has the highest critical weight, thus it is ranked 1st. This shows us how AHP can guide us to decide which option is best among multiple courses by comparing them based on their criteria weight and help us to decide which course to choose.

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Impact of Active Learning Methods on Students' Learning and Course Results

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Abstract : Active involvement of the students during classroom sessions is becoming a tough task for those teaching to higher classes and upto some extent for those teaching in the schools. The reason is the change in learning styles of the students which ultimately call for the change in teaching styles too. In order, to satisfy the students in the world of competition today, the use of active and cooperative learning techniques is increased in the engineering institutes. This helps to increase the quality of technical education imparted by the institutes and help them to be distinguished due to the enhanced index of students' learning. The present study reports the application of some of the active learning techniques that include the Jigsaw technique, Muddiest point technique, Concept mapping, Case Study and Team-based learning. The different techniques are used for different segments of the 'Hydraulics and Pneumatics' course delivered to final year Automobile Engineering students studying in the final semester. The course contents, methodology of application of techniques, the students' responses and outcomes of application of the active learning techniques are discussed in the paper. It is concluded that proper planning, availability of resources and students' cooperation make it easier to apply modern-day teaching techniques. The positive change in students' learning level, their graduate attributes, passing percentage and average marks is noticed by doing the above-mentioned experiments during the classroom sessions.

Keywords : Active learning; Classroom sessions; Graduate attributes; Students' learning level; Students' responses.

1. Introduction

Engineering education has now shifted its focus from output-based education to outcome-based education. The achievement of graduate attributes matters a lot for passing out graduates as it speaks about the abilities of the graduates such as communication, teamwork, self-learning, problem-solving ability, subject knowledge etc. This necessitates that students learn every course curiously and achieve the expected outcomes. The essential elements of engineering education that involve curriculum design, delivery of instructions and assessment methods, are affecting the attainment of outcomes of a particular course and in turn attainment of outcomes of any program. The effectiveness of the

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delivery of instructions decides the success of the teaching-learning process that contributes to improve the student learning index. Activity- based learning is needed to attract the students to classes and make them experience joyful learning. This is the reason that active and cooperative learning techniques are widely used these days in engineering education to enhance students' attendance and participation during classroom sessions.

2. Literature Review

Though the implementation of active and cooperative learning techniques has become popular in recent times, the research outcomes can be found from research work carried out over the years. This section presents some of the research findings on active and cooperative learning methods. Nastasi and Clements (1991) carrying out research found the answers about the formation and implementation of cooperative learning groups. The factors affecting the efficacy of the approach are discussed in the work. Patrick and Anderson (2000) presented the results of the experiments to compare role-playing and collaborative exercises to the traditional style of teaching and found positive outcomes. Amburgh et al. (2007) developed an active learning inventory tool and found it valid and reliable to measure active learning in the classroom. Barroso (2010) used cooperative learning and problem and project-based learning for teaching an undergraduate course and found that the techniques help to expose the students to alternate solution strategies for solving the same problem. Stowe (2010) has presented the experiments with a writing activity; a one-minute paper and highlighted its importance due to its ability to enable the students to stop, focus their thoughts and address their questions before leaving a class. Jain and Dwivedi (2014) critically examined core elements of active, collaborative, cooperative and problem-based learning methods to find evidence for the effectiveness of active learning. The study helps to understand the assessment of active learning methods to see if they work. Sheng and Hu (2014) implemented an engineering application case-based teaching method for Hydraulics and Pneumatics course. The authors have used various engineering application cases of hydraulics and pneumatics to correlate theoretical knowledge with engineering practices. Meti and Giriyapur (2015) effectively planned theory sessions, laboratory sessions and course projects of hydraulics and pneumatics to enhance students' performance. During laboratory sessions, automation studio software and hands-on kits were used for designing and simulating hydraulics and pneumatics circuits. The experiments were conducted using a laboratory anatomy approach and finally, students completed a course project by selecting industrial application based problem definition. Renata Fortuna Ramos (2015) implemented amodified version of muddiest point technique for the project based bio-instrumentation course. Based on the muddiest points reported by the students, a written document covering students' questions and resource material to help them obtain additional information to address their queries was shared with the students. The impact of implementing the technique was assessed using the final project grades and was found to improve the same.

Gillies (2016) reviewed developments in the research on cooperative learning and studied the factors on which its effectiveness depends. Tharayil et al. (2018) discussed the strategies to reduce students' resistance to the use of active learning techniques for classroom teaching. Kalyana Chilukuri (2020) have used few online active learning tools to deliver an elective course 'Routing and Switching Concepts' and discussed impact assessment of the suggested framework with the help of students' responses.

The literature review shows that researchers have experimented with different active learning techniques and assessed their effectiveness. The pace of experimentation with the use of such techniques has been considerably increased in the recent past. With time, there has been continuous addition of several techniques to the list of active learning techniques. The literature review revealed that though active learning methods have been used for the course delivery in the past, the development of understanding about the implementation of such techniques need more experiments to gather data for different courses, under different conditions, and assess their effectiveness. An attempt has been made to apply different active learning methods to deliver the entire course over the semester long period. The research work presents the application of active learning methods including the muddiest point technique, case study, jigsaw technique, concept mapping and team-based learning to deliver the 'Hydraulics and Pneumatics' course to the final year B.Tech. Automobile engineering students. The active learning methods have been selected to serve multiple objectives such as exposing the students to real life applications, enabling them to interact and learn

during the classroom sessions, asking them to design, draw and connect different circuits, helping them to understand difficult concepts in a simple way, and establishing a mechanism so that students will highlight the muddiest points to address them subsequently. The objective is to study the effect of change in the learning environment on the students' participation, learning and the course results.

3. Research Question

In Outcome-Based Education (OBE) today, activity-based teaching-learning is the need of time to engage and involve the students and to ensure achievement of the course outcomes. Due to the higher difficulty level of the 'Hydraulics and Pneumatics' course, achieving higher values of average marks and the passing percentage is a challenge for a course teacher. The present work is an attempt to overcome these challenges by using active learning techniques for course delivery. The number of students enrolled for the course were 21 and the different activities were implemented throughout the semester.

4. Methodology

The 'Hydraulics and Pneumatics' course is offered as an elective course to final year B.Tech. (Automobile Engineering) students. The course delivery was planned to use different active learning techniques during the semester-long period. The different techniques used were Jigsaw technique, Concept mapping, Case study, Muddiest point technique and Team- based learning. The methodology of the application of different techniques and the outcomes are discussed in the subsequent sections.

The students were given a brief introduction about the active learning methods used and were clarified about its objectives. The evidence of implementation of the different methods was collected in the form of photographs. The report format was shared with the students to summarize their findings after visiting the workshops under the industrial application-based learning method.

The data for assessment of the impact of the active learning methods was collected in the form of performance of the students during In-Semester Evaluation (ISE), Unit Test (UT) and End Semester Examination (ESE). The data was also collected using the feedback survey expecting students' responses on the active learning methods implemented, and their effectiveness. The survey questionnaire is validated by referring it to a faculty member who taught the same course earlier. The course results were analysed to find the average marks and percentage of the students who passed the course. The attainment of course outcomes was also calculated by using the students' results in ISE, UT and ESE. The student's responses to the feedback survey were also analysed to get the qualitative data, to conclude on the students' perceptions and to summarize their views on the active learning methods implemented for the course under consideration.

5. Active Learning Techniques

A brief introduction to different active learning techniques is presented in this section.

A. Jigsaw Technique

It is a cooperative learning technique in which students were divided into groups of 4 to 5, and each of the students in a group (first group) were given a topic to study independently. The students from each group with the same topic were then asked to form an expert group. The students discussed and shared their learnings on the same topic. In this way, a common understanding of the topic of interest was reached through cooperative learning in a group. The students were again asked to join their original group to finally share knowledge about their topic in the group, where every individual has a different topic to study. In this way, all the students shared expertise about their topics with each other and thus enabled a class to thoroughly understand different topics. Fig.1 shows the first groups (Phase I) while Fig. 2 shows students working in the expert groups (Phase II).

B. Case Study

The students visited an industry or a workshop to identify and study industrial and societal applications of hydraulics. They were expected to submit the report including the photograph of the application where the hydraulic system is used,specifications of the system, working of the system and learning outcomes. Every student could see different components of the hydraulic systems and connect his / her classroom learnings to real-life applications using fluid power.

The students after interaction with each other could list several applications and learn how hydraulic systems are used to meet the demands of different applications. They had shared the outcomes of their visit with each other and had known details of components used in various applications. Two-wheeler lifter, excavator, dumper etc. are some of the applications seen by the students. Fig. 3 shows the format of a case study report submitted by the students after the visit. Fig. 4 shows a student observing a hydraulic two-wheeler lift during his visit to a workshop.



Fig.1: Jigsaw technique (first group)



Fig. 2 : Jigsaw technique (Expert group)

C. Muddiest Point Technique

The technique was used after the course content was delivered in the class and the students were expected to write on a page about the concept that they felt most difficult to understand. It helped the teacher to know the learning of the concepts taught and thus helped to identify the gap, and further to take appropriate action to bridge the gap. Fig. 5 shows students independently writing the muddiest points while seating one on each bench.

B. Concept mapping

The technique involves listing different concepts/terms related to a given topic, categorizing them into different groups and then arranging different concepts from top to bottom based on their relationship with each other. This helped the students to list and define avrious concepts from the given topic of interest.

Case Study Report

Final Year B.Tech. (Automobile Engg.) **Hydraulics and Pneumatics**

Name of the Student:

Roll No. :

1.Title of the Problem:

Identification and study of the real life application in which hydraulic system is used to get the required work output.

2.Details of the Application:

2.1 Location (i.e. in the Industry / Society)

2.2 Purpose for which the Hydraulic System is used in the application:

2.3 Photograph (including the student) :

3.Block Diagram of the Hydraulic System

4.Hydraulic Circuit Diagram:

5.Details of the Components of the Hydraulic System:

Sr. No.	Name of the Component	Function / Description	Specifications

6. Description of the Working of the Hydraulic System :

Name and Signature of the Student **Name and Signature of the Course Teacher**

Fig. 3 : Format for submission of the Case Study Report (Template)

'Hydraulic Systems' was the topic given to the students to prepare a concept map using different terms related to it. Fig. 6 shows a group of students who are working together to develop a concept map.

E. Team-based learning

In this technique, the student groups with 5 to 7 members in a group were formed and were asked to develop different pneumatic circuits using a pneumatic trainer kit. Every group prepared different circuits including sequencing circuits, speed- control circuits, the circuit to control double acting cylinders etc. They were also asked to draw the same circuit on the paper. The students worked as a team to design, draw and connect a circuit to solve different problems involving a sequence of operations, speed control of the cylinders during extend or return stroke etc. Fig. 7 shows a team of students involved in the discussion to prepare a circuit for a given application. Fig. 8 shows a pneumatic circuit developed by the student teams.



Fig. 4 : Student observing hydraulic two-wheeler lift in a workshop



Fig. 5 : Students engaged during Muddiest Point Technique

The activity allowed the students to enjoy experiential learning. They have gone through every step to finally develop a pneumatic circuit by selecting appropriate elements and by logically connecting each element in a proper sequence. They have realized the importance of designing precise circuits to ensure output expected from the circuit i.e. desired motion, velocity and force.



Fig. 6 : Team working for concept mapping



Fig. 7: Team of students working to prepare a pneumatic circuit

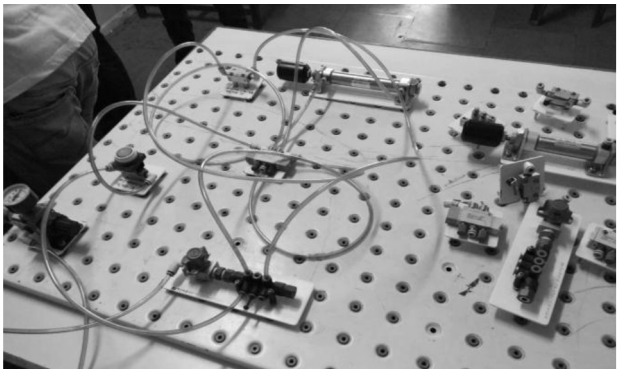


Fig. 8 : Pneumatic circuit prepared at the end of the activity

6. Results And Discussion

This section presents the course results, attainment of course outcomes and impact assessment of the active learning methods implemented for the course delivery. The impact assessment has been done using the following tools.

1. Comparison of the course results with the previous year results.

2. Comparison of attainment of Course Learning Outcomes with the previous year's attainment.

3. Analysis of students' responses to an active learning survey.

A. Improvement in course results

Table 1 shows the comparison of results for the 'Hydraulics and Pneumatics' course for the previous and current academic year.

Table 1 : Comparison of results for hydraulics and pneumatics course

Parameters	Academic Year	
	Previous Year	Current Year
Average marks in ISE (out of 20)	15.09	17
Average marks in UT 1 and UT 2 (out of 30)	18.57	16
Average marks in ESE (Out of 100)	48.54	59.8
Result of ESE (passing %)	78.79	95

The assessment of the course is done throughout the semester (continuous assessment) using assessment tools including In- Semester Evaluation (ISE), Unit Test-1 (UT 1), Unit Test-2 (UT-2) and End Semester Examination (ESE). The results show that there is a little improvement in the average ISE marks from 15.09 to 17. There is little fall in the average marks in UT 1 + UT 2 from 18.57 to 16. This is probably because Bloom's taxonomy level of questions was comparatively high and the impact of all the techniques together was yet to be seen at the mid of the semester. Despite questions with a higher level of Bloom's taxonomy and 100 marks question paper (50 marks

B. Comparison of attainment of Course Learning Outcomes with the previous year's attainment.

1) Course Learning Outcomes

Following are the abilities expected to be developed in the students after successful completion of the course.

1. Describe basic properties of fluid and important principles of hydraulics and pneumatics with their applications.

2. Identify various components of Pneumatic and Hydraulic control systems.

3. Design Hydraulic and Pneumatic Circuits for given engineering applications.

4. Diagnose probable causes of failure of components of hydraulic and pneumatic circuits.

2) Assessment Tools

The direct tools used for the assessment of the attainment of course learning outcomes and their weightage is given in Table 2 below (Desai and Patil, 2016).

Table 2 : Assessment Tools

	Assessment Tools			
	ISE	Unit Test-1	Unit Test-2	ESE
Weightage (%)	20	15	15	50

The questions in the question papers of Unit Tests and End Semester Examination are mapped to relevant course learning outcomes of the course. The analysis of question wise marks scored by each student and CO mapped to respective question helps to find attainment of each Course Outcome based on the performance of the students in various examinations of the course conducted during the semester.

2) Comparison between CO attainment levels for the two consecutive years

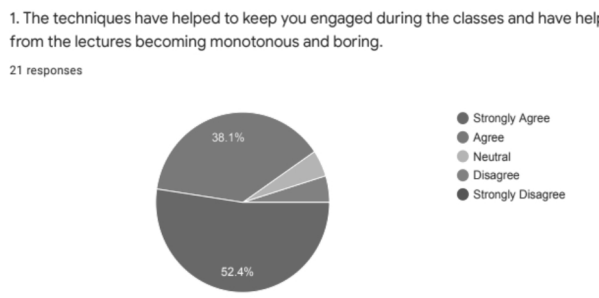
Table 3 shows the comparison between the level of attainment of COs for the previous and current academic years.

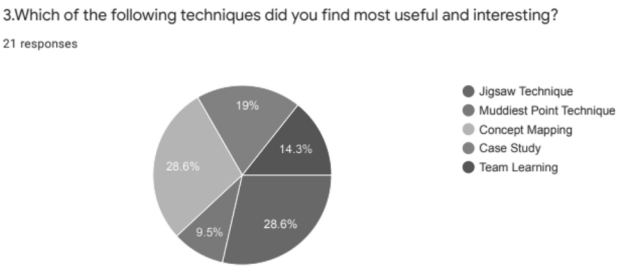
Table 3: Comparison Between Level of Attainment of Cos for the Previous and Current Academic Year

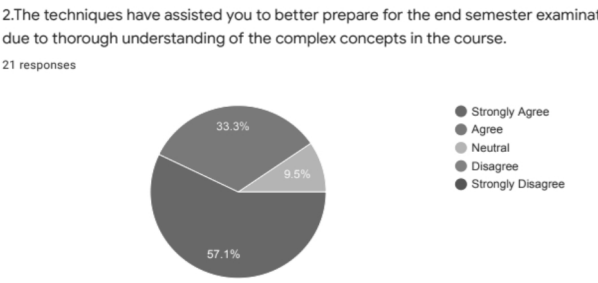
Course Outcomes	Level of Attainment (%)	
	Previous Year	Current Year
CO 1	91	95
CO 2	86	74
CO 3	69	63
CO 4	79	77

Table 4 : Active Learning Survey (template)

Sr. No.	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	The techniques have helped to keep you engaged during the classes and have helped from the lectures becoming monotonous and boring.					
2	The techniques have assisted you to better prepare for the end semester examination due to a thorough understanding of the complex concepts in the course.					
3	The technique such as 'Case Study' has given you an opportunity of exposure to real-life problems where Hydraulics and Pneumatics systems are used to get the necessary power to exert the load in the application of interest.					
4	Activity-based teaching gave you chances to interact with your peers and learn from them.					
5	The learning environment during classroom sessions has allowed you to work in teams and improve your communication.					
6	The motivation to and promotion of interactive learning in the classrooms has improved your problem-solving ability.					
7	Overall, you feel that ability has been developed in you to design a hydraulic and pneumatic circuit for any industrial application.					
8	Which of the following techniques did you find most useful and interesting? (i) Jigsaw Technique (ii) Muddiest Point Technique (iii) Concept Mapping (iv) Case Study (v) Team Learning (vi) All of These					
9	Please express your experience of attending the 'Hydraulics and Pneumatics' lectures during the semester-long period. .... ……					









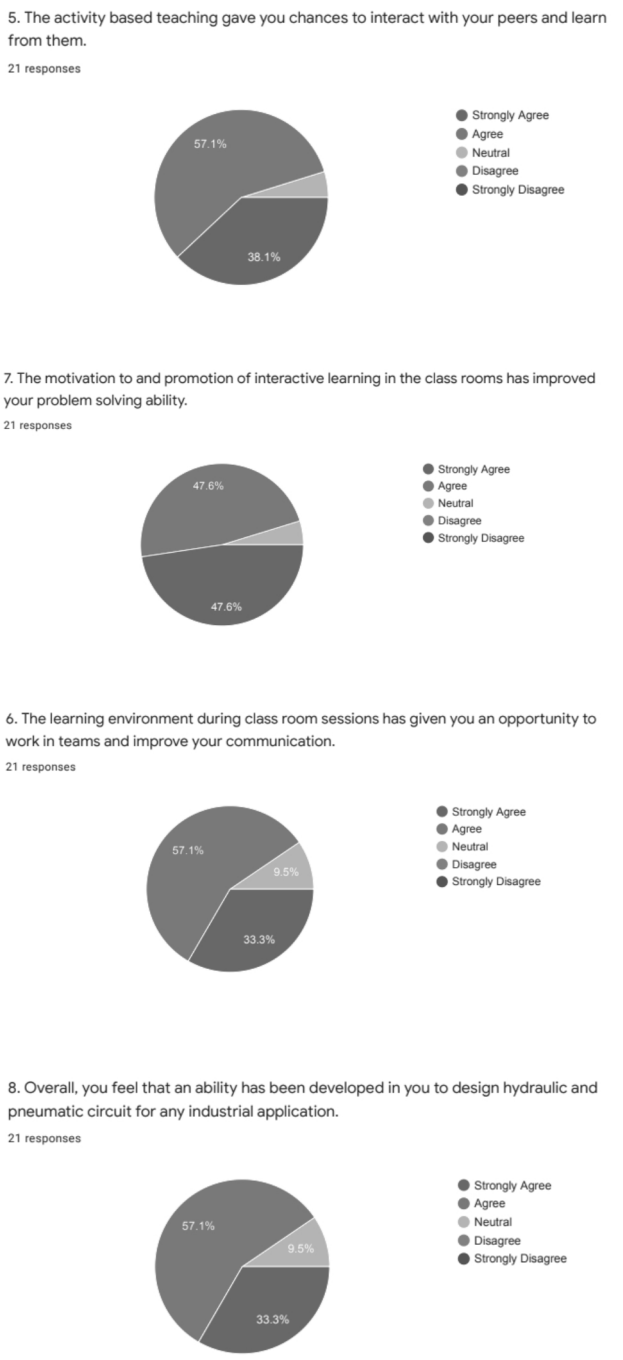


Fig. 9 : Summary of Responses of the Active and Cooperative Learning Survey

The attainment calculated is threshold-based with ISE threshold 60 % and ESE threshold also 60 %. The attainment is increased for CO1, decreased up to a certain extent for CO2 and CO3, and is almost the same for CO4.

A. Analysis of students' responses to active learning survey

To measure the effectiveness of the active learning methods used during the delivery of course contents, an active learning survey was conducted using Google forms (Fig. 9). The survey template is shown in Table 4. The summary of findings of the students' responses to the statements/questions is discussed below.

- 90.5 % of the students believe that the techniques have helped them to be involved during the classes.
- 90.4 % of the students feel that they could better prepare for the end semester examination because of the clarity about complex concepts in the course.
- Among different techniques, the concept mapping and Jigsaw technique were most liked by the students (28.6 % for each technique)
- 95.2 % of the students expressed that the use of active learning techniques have given them exposure to real-life problems where Hydraulic and Pneumatic systems are used.
- 95.2 % of the students feel that it allowed interacting with their peers and learn from them.
- 90.4 % of the students feel that the classroom environment allowed working in teams and improving their communication.
- 95.2 % of the students believe that active involvement during classes has helped them to improve their problem- solving ability.
- 90.4 % of the students agreed that they can design hydraulic and pneumatic circuits for any industrial application.
- Finally, the students while expressing their experience have said that they have understood basic concepts and understood the industrial applications of hydraulic and pneumatic systems. They said that the activities helped them to develop an interest in the course and they are now able to prepare and draw the circuits.
- Few students have given suggestions and expected additional efforts to implement the suggestions received through the muddiest point technique.

The analysis of both the course results and students' responses to the survey questionnaire indicates that the use of several techniques has made available a platform for learning where students are actively involved during the classroom sessions. The implementation of active learning techniques has helped to create an environment and support system for self- learning by the students. It has helped to create confidence among the students that active learning makes the understanding and application of difficult concepts easier.

7. Conclusions

The experiments were conducted in the classroom to use several active learning methods and study the effect on students' learning and achievement of graduate attributes. The course considered was 'Hydraulics and Pneumatics' which was delivered to the students of final year B.Tech. Automobile Engineering. The activities were conducted after regular intervals of time during the semester. Following are the conclusions derived.

- The comparison of the course results with previous year results has shown that the passing percentage in ESE is increased by 21 % while the average marks in ESE are increased by 23 %.
- The comparison of the level of attainment of COs indicates that there is an increase in % attainment for some of the COs while there is a slight decrease for some other Cos.
- It was experienced that the students' participation in the classroom was increased which resulted in the development of abilities such as communication, working in teams and problem-solving ability.
- It thus concludes that active participation of the students avoids the lectures from becoming monotonous and helps to develop an interest in the course under consideration.

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Problem-Based Learning Experience in Civil Engineering

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Abstract : The activity-based learning (ABL) is essential to be incorporated in teaching-learning process to attain graduate attributes in engineering education. Problem-based leaning (PBL) is one of such activities. This paper demonstrates the crafting of authentic PBL problems in Civil Engineering discipline. The problems can be of different durations and can be segregated in to various phases based on the knowledge acquired by the students and problem requirements. The experience of one phase of a PBL problem carried out is promising in exhibiting the improvement of skills of the students in solving the problems in the real-world scenario. PBL activity if incorporated in engineering curriculum will definitely result in enhanced Teaching-Learning process.

Keywords: Accreditation; Activity Based Learning; Problem-Based Learning; Civil Engineering.

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1. Introduction

The improvement in academic quality in the present state of the art Engineering Education, not only plays a vital role in producing employable graduates but also equip the graduates with blend of entrepreneurial skills, social responsibility and accountability along with professionalism. To accomplish such a goal, the accrediting bodies are established to check the quality of higher education. The National Board of Accreditation (NBA), in India an independent autonomous body with the objectives of assurance of quality and relevant technical education, brought a mechanism of accrediting the programs offered by technical institutions. After being the permanent signatory of the Washing Accord on 13th June 2014, the NBA accreditation process follows Outcome Based Education (OBE) whose philosophy is "Keep the Goal in Mind and Work to Achieve it". That is to set the clear education goals (outcomes) and then Design Educational Process that enables the students to meet those goals.

The outcomes of such an education system makes the Graduate Engineers well-equipped with Knowledge, Skills and Attitudes which forms the basis for OBE. These outcomes or objectives are defined at different levels of educational process right from course levels (Course Outcomes - Cos), program levels (Program Outcomes – POs and Program Specific Outcomes - PSOs) up to and after completion

of 4 to 5 years of program (Program Educational Objectives – PEOs).

The accreditation process of NBA involves four phases: (1) Defining the objectives and outcomes at the institute and program levels, (2) Designing a well-structured Curriculum to meet all the defined objectives/outcomes, (3) Development of a well-designed and effective Teaching-Learning Process and (4) Framing Suitable Assessment Methods and Tools to check the learning of graduates and monitor them through a continuous improvement process. Revised Bloom's Taxonomy is employed to measure the skillsets attained by the graduates.

In this regard, the Teaching-Learning phase as well as assessment methods look for an apt professionalism in the faculty members. There are two categories of professionalism, namely Restricted and Extended Professionalisms. The restricted professionalism emphasizes only on high level of classroom competence such as teaching skills and good relationships with students. On the other hand, the extended professionalism demands additional attitudes in the teachers such as their work in the wider context of community and society, substantiated by theory, research, and current exemplars of good practice. Hence, it is utmost important for a teacher to exhibit extended professionalism to support greater learning capabilities in the students. The extended professionalism of teachers helps in meeting the well-crafted Graduate Attributes or Program Outcomes (POs) of NBA, which encompass all the needs of the present-day educational requirements.

To address these POs, the incorporation of Activity Based Learning (ABL) in Teaching-Learning process becomes essential. The history of ABL is sketched back during 1944 around World War II. Mr. David Horsburgh, British man, who came to India and settle down here, is considered as pioneer of ABL. ABL is a pedagogical approach wherein the various modes of activities are incorporated. The various activities of ABL (not limited to) are: Quizzes, Group Discussions, Educational Games, Brainstorming, Problem Solving, Debates, Discovery Learning, Projects, Field Works, Experimentation, Concept Mapping and many more. In this pedagogy, students learn by performing activities in the simulated work environment. In addition, they also explore themselves to take on the real-world task. In this pedagogy, both student and teacher become active participant. The core objective encompasses that learning should be based on doing some hands-on experiments and activities. ABL not only helps in maintaining the learning curve nearly constant but also enhances abilities of the students in participation, analyzing ability, critical thinking, knowledge sharing, communication, team-work, problem solving, self-driven learning, concerns about environment and society and many more. The present study focusses on the implementation of PBL in Civil Engineering stream to support in enhancing the attainment of graduate attributes of the students. Amongst many PBL problems crafted, the details of one problem on Planning and Designing of Residential Building is presented.

2. Problem-based Learning

Problem-Based Learning is a type of ABL in which learners define a process in finding the solution to the complex problem (frequently real world) by using one or more concepts or principles along with the required information processed during their learning. PBL is a methodological Teaching-Learning process wherein the teacher creates nearly a real world and unfamiliar situation to the learners, in which they are expected to solve the problem using the acquired knowledge, skills, attitudes and application of the same in the context of the unfamiliar situation. Further, the learner shall possess the additional required knowledge to solve the problem, thus becoming self-directed learner.

The pioneering work on this novel approach in Teaching-Learning was done by Barrows and Tamblyn (1980), who define the approach as the learning that results from the process of working towards an understanding or resolution of a problem. Even though, the PBL has its origin in the Education of Law wherein the situation of court of law is created in the classroom for simulating the legal practice, Barrows and Tamblyn (1980) devised it in the School of Medicine at McMaster University in Canada in the 60s and 70s with its first application to the sciences. Since then, PBL has made its signature in different areas of study, including the various branches of engineering and architecture (Mahendru and Mahindru, 2011; Jamaludin et al., 2012; Rodriguez and Fernández, 2016; Holmes and Beagon, 2015; Larson et al., 2018; Thakur et al., 2018b; Barg et al.,2000 and many more).

Thakur et al. (2018a) presented a detailed review on the effect of PBL in developing various skills such as critical thinking, problem solving, self-directed and

self-regulated learning skills, reasoning skills, leadership skills, team skills and cognitive skills considering different layers of learning from schools to workplace. They further presented (Thakur et al., 2018b) the implementation of PBL in learning biology by 9th class students. They reported the enjoyable experience of the students in learning biology at their own pace along with finding new things besides the syllabus prescribed in the textbook. Kuvac and Koc (2019) found that PBL is more effective than the traditional teaching approach in the development of environmental attitudes in preservice science teachers. The study was undertaken with an experimental design having pre-test and post-test control group consisting of 51 junior preservice science teachers.

According to John Dewey (1916), the first approach in any institute is that the teacher shall create and present an empirical situation replicating the real-world outside the school, which demands the students, their experience in handling the situation, the sort of occupations that interest and engage activity in ordinary life. They give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally results. According to Boud, the principal idea behind PBL is that the starting point for learning should be a problem, a query, or a puzzle that the learner wishes to solve (Boud and Feletti, 1991). The common features involved in PBL approach are:

1. Learning is initiated by a problem,

2. Problems are based on complex and real-world situations,

3. Information needed to solve problem is not given initially, however students identify, and

4. Find and use appropriate resources and work in permanent groups.

More importantly, in this approach, the teacher becomes a dynamic facilitator who might change his role as group member, dialogue-based facilitator or consultant as per the demand of the situation.

3. Crafting Pbl Problems

An effective problem is the heart of PBL and crafting an engineering problem is a challenging task. In general, problems can be classified into three different types: fictional, authentic and real. Though, real engineering problems are hard to find, and if any, they cannot be directly adopted for academic perspectives as the actual working environment cannot be easily modelled and simulated. Further, the real field engineering problems are highly technical for students to visualize, and difficult for educators to transform into written format. Hence, often modification and simplification are necessary for real problems to be used for classroom benefits. One way to deal with this issue is by crafting the problems that cover the intended learning outcomes and customized to the industrial standards which promote higher-order thinking, lifelong learning and team working skills. Therefore, crafting the authentic PBL problems is always a good alternative and is the most preferred by PBL practitioners.

The crafting of a PBL problem is both an art and science. PBL needs to create interest in students, motivate them to apply the fundamentals of the theory and practical learnt, induce zeal for higher self-learning and ensure successful implementation of solutions. Studies have revealed that the application of the scientific principles in PBL have promoted effective learning and implementation. Apart from creativity, the crafting engineering problems in PBL curriculum requires a lot of effort that includes a study of practical knowledge related to the course and also communication with the expert personnel from industries. The problems have to be industrial-based and never subject-driven. The PBL problems shall incorporate five main principles such as: Authentic and Realistic (if not real) [P1], Constructive and Integrated [P2], Offer Suitable Complexity [P3], Promote Self-directed and Lifelong Learning [P4], and Stimulate Critical Thinking and Metacognitive Skills [P5] and to cover the intended learning outcomes (Jamaludin et al., 2012).

Designing a PBL problem in engineering consists of several steps that may require iteration, as described below (Jamaludin et al., 2012):

Step-1: Identification of the intended learning outcomes. Here, the gap between knowledge and skills in a problem should not be too large, which otherwise make the students to give up. However, if the gap is large, it is advisable to fragment the problem into parts/phases with certain outcomes at each phase before the final solution.

Step-2: Identification of the real problem, work setting and demand at the workplace where the learning outcomes fit. This requires inputs and opinion from industrial experts.

Step-3: Writing the first draft of problem that indicate the learning outcomes achieved through the problem and the demand at the workplace. The problem can be presented in the same format as experienced in the professional practices. However, best way is creating a similar situation as that in the field. If possible, the required resources may be indicated and the possible approaches may be recommended. Problems can be presented in different forms such as word document, presentation, letter or e-mail and written in present tense. The problem must contain objectives and expectations from the students instead of procedures and methods.

Step-4: The guidelines in the form of expected possible findings and learning issues that could arise are prepared to avoid students' learning going off-track. In addition, grading rubric prepared for a particular problem shall be shared with the students to show them the outcomes and expectations of the problem.

Step-5: Packaging the problem for presentation is an added-value that will aid in engagement and immersion. The work sheets with fictitious company headings can give a feel of more realistic situation.

Step-6: Once the problem is crafted, it requires to be reviewed, revised and refined to ensure that it is solvable and can be solved by the students in the given timeframe. The feedback from colleagues teaching the same course is necessary before the problem to be distributed. Steps 1 to 6 are iterative in nature before delivering the problem to students (Step-7).

4. Pbl Problems in Civil Engineering – An Insight

Crafting of PBL problem for engineering courses is challenging and fascinating. PBL is practiced in all the disciplines of Engineering. Mahendru and Mahindru (2011) employed PBL concept for students of Electronics and Communication Engineering in SRM Group of Professional Colleges, Lucknow and found that the students' learning with PBL is much better than the traditional teaching. A PBL problem was crafted to Chemical Engineering students by Jamaludin et al. (2012) in Universiti Teknologi, Malaysia. The problem was crafted for Process Control and Dynamics. They observed that the PBL studies motivated the learning in students along with skill development and engineering perspectives. Barg et al. (2000) designed a PBL course to address the challenges in foundation course in Computer Science. PBL concept is also experienced in Civil Engineering field. Holmes and Beagon (2015) crafted two PBL scenarios for third year students at School of Civil and Structural Engineering in Technological University, Dublin. Larson et al. (2018) used PBL in understanding the foundation knowledge in real-world problem at Arizona State University, USA. Butan (2007) reported that the hybrid model of PBL and Traditional teaching learning increase the knowledge base of the students along with problem solving, independent and critical thinking, which are the essential features of the future engineers.

Table 1: Pbl Problems in Civil Engineering - Examples

Sl. No.	Problem Statement
1	Planning and Designing of Residential Building
2	Proposal for Integrated Township with a Pre-Engineering Building
3	Energy Efficient Design of Buildings
4	Data Base for Cadastrial Maps Using Co -Ordinates Systems
5	Design of Water Distribution System for a village
6	Rainwater Harvesting
7	Water Quality Analysis and Remediation
8	Lake Eutrophication: Causes and Remediation
9	Instrumental and Analytical Tools for Material Characterization
10	Preparation of Fly Ash Coarse Aggregates and its Effective Utilization in Concrete
11	Concrete Distresses and Repair
12	Quantification of Severity of Damage in Structures
13	Analysis of Bridge cum Barrage
14	Design of Industrial Structure
15	Seismic Evaluation and Strengthening of Buildings
16	Earthquake Resistant Design of Building Structure by Selecting a Suitable Lateral Load Resisting Structural System
17	Effective Use of Construction Management Tools in Moderating Delay in Projects
18	Foundation Design on Expansive Soils
19	Strategies for Road Safety
20	Pavement Management System, Effective Tool for Government Agencies
21	Design and Economical Analysis of Canal Network
22	Planning and Designing of check dam
23	Quantitative Analysis of Salinized Soil and Its Remediation

The previous studies demonstrate the implementation of PBL on a specific topic of an Engineering stream. However, in this article the experiences of PBL practice crafting number of problems in authors institute is presented. Some of the typical PBL problems crafted in Civil Engineering

stream are listed in Table-I. It is to be noted that the list is not limited. All the PBL problems are of four cycles with total duration of 16 to 20 weeks. The duration of each cycle depends on the specific problem. The details of one of the problems "Planning and Designing of Residential Building" is presented in the next section.

5. Problem: Planning and Designing of Residential Building

This PBL problem is crafted for 16 weeks duration having four cycles as detailed in Table-II. It is a special PBL problem designed for the students to undergo for three successive years from second year to fourth year based on the acquired knowledge. The problem is crafted in such a manner that the learning outcomes of successive cycle are built over the previous cycles, hence addressing the principle P2. The workflow in each cycle follows the phases as indicated in Figure 1.

Table 2 : Details of Pbl Problem

Cycle	Problem Statement	Duration	Principles of PBL	Year
1	Preparation of plan of residential building	2 weeks	P1 to P5	II year
2	Preparing the 3D soft model and architectural model along with use of green building concept and documentation for approval process from the concerned authority	3 weeks	P1 to P5	III year
3	Structural design of various components using STAAD.pro software	5 weeks	P1 to P5	III year
4	Estimation of total cost, preparation of inventory (material, labour and machinery) schedule, preparation of working drawings	6 weeks	P1 to P5	IV year

Note : Principles of PBL - P1: Authentic and Realistic, P2: Constructive and Integrated, P3: Offer Suitable Complexity, P4: Promote Self-Directed and Lifelong Learning, P5: Stimulate Critical Thinking and Metacognitive Skills.

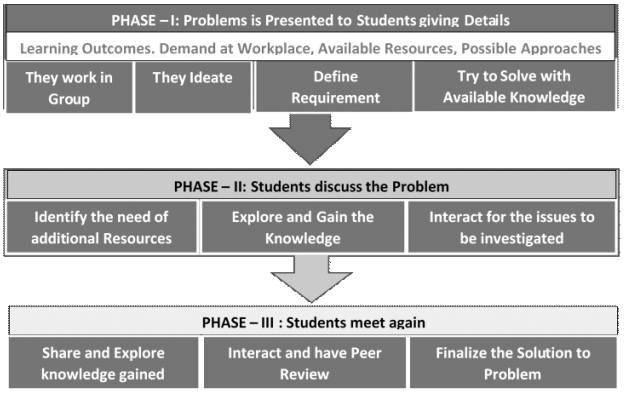


Fig. 1 : Workflow diagram

Table 3 : Presentation Steps of Cycle-i

Steps	Particulars	Details
1	Learning outcomes	• To prepare the plan of a residential building for a client as per the site condition and requirements **[P1]**
2	Problem and Appropriate Demand	• Interaction with the client and collect the information regarding the site (plot size, location, site map etc) and their requirements and limitations
3	Resources to be collected	• Site Map
	Prior Knowledge	• Building Materials and Construction • Building Planning and Design • AutoCAD concepts
4	Solution Guidelines	• Each team members shall prepare minimum 2 alternate plans • Select minimum 3 alternative plans (amongst 8) meeting the requirements of clients and guidelines [**P2**] • Preparation of AutoCAD plans along with interior details of 3 selected plans for discussion with client [**P5**] • After finalization of the plan, the submission drawing shall be prepared that include underground drainage, water supply, electricity plans [**P4**]

Cycle-1: Preparation of Plan of Residential Building

This cycle is designed for second year undergraduate students of Civil Engineering particularly for even semester (IV Semester). It is designed for short duration (2 weeks) so as to create interest in students and make them to enjoy solving the problem. Four students in a group are considered. The details of various stages of this cycle are furnished in Table-III.

Cycle-2: Preparation of 3D and Architectural Plan

Cycle-2 is crafted for third year students who will take it up in odd semester (V Semester). It is of 3 weeks duration involving certain self-driven learnings such as 3D architectural drawing and detailing and greenhouse concepts. This cycle is built on cycle-1 wherein the students will work on their finalized plan in previous cycle. The details of steps involved are given in Table-IV.

Cycle-3: Structural Design of Components using STAAD.pro

This cycle is taken up at third year in the even semester (VI Semester) after acquiring prior knowledge. It is of 5 weeks duration. This cycle requires the students to learn STAAD.pro software and prepare structural drawings. Table-V gives the learning outcome, problem and demand of the problem, requirement of resources and prior knowledge along with solution guidelines.

Cycle-4: Cost Estimation and Preparation of Inventory

This is the last cycle of this PBL designed for fourth year (VII and VIII Semesters) students for 6 weeks duration. The learning outcome, problem and demand of the problem, requirement of resources and prior knowledge and solution guidelines are furnished in Table-VI

Table 4 : Presentation Steps of Cycle-ii

Steps	Particulars	Details
1	Learning outcomes	• To prepare 3D Model of finalized plan • To create an architectural model • To identify locally available greenhouse materials • To create documents for approval from the concerned authority
2	Problem and Appropriate Demand	• Preparation of a 3D soft and architectural scaled model • Alternative locally available materials leading to green building concept are to be implemented after discussion with client
3	Resources to be collected	• Knowledge of locally available alternative materials and their suitability • Guidelines of approval authority • Document list required for submission to approving authority
	Prior Knowledge	• 3D software [**P4**] • Alternate building materials [**P4**] • Study on documentation process for approval [**P4**]
4	Solution Guidelines	• 3D Model shall be prepared as a team [**P3**] • Using card boards, an architectural model shall be prepared [**P2**] • Survey for locally available material to find their suitability • Discussion on the available alternate materials and finalize them before presenting to the client. • Presentation of the model to the client along with recommendation to use locally available to incorporate greenhouse effect. [**P5**] • Documentation shall be done for getting approval from approving authority.

6. Implementation

The concept of PBL was introduced to the students of second year (IV Semester) along with the advantages of the same. The problem was presented in the form of presentation explaining the learning objectives of the problem and the expected outcomes of the activity along with timeline of 2 weeks. Initially, the students show dis-interest in the activity. However, with the explanation of learning outcomes as required in the professional practices, the students shown their curiosity to carry out the PBL activity and worked in group of 4 members. The students were asked to interact with fictious clients, who gave their site details along with their requirements as detailed in Table-VII. The site size was 30 feet × 40 feet with 40 feet side parallel to north-south direction and 30 feet side adjoining the road.

In the first week, each member of the team prepared two residential plans. They are being asked to deliberate in the team side parallel to north-south direction and 30 feet side adjoining the road.

Table 5 : Presentation Steps of Cycle-iii

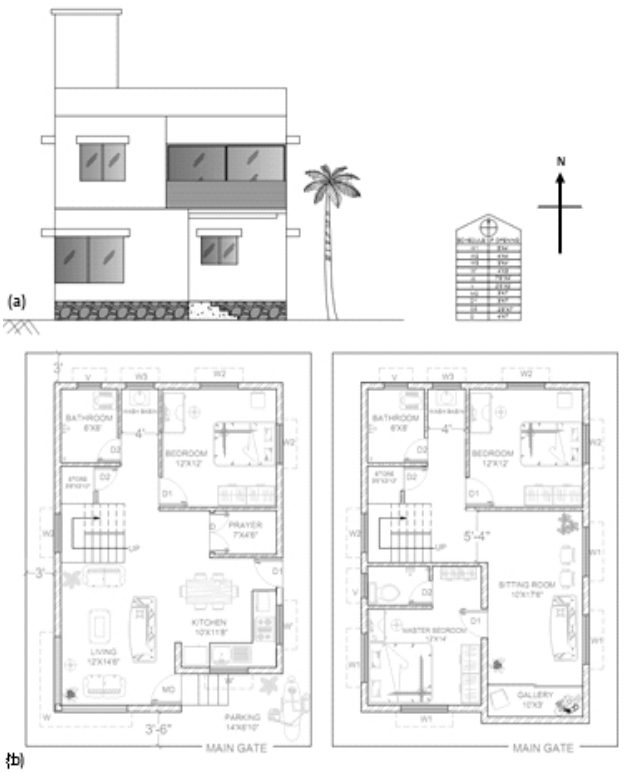


Fig. 2 : (a) Front elevation, (b) Floor plans (Left: Ground Floor, Right: First Floor) of residential building

In the first week, each member of the team prepared two residential plans. They are being asked to deliberate in the team regarding their individual plans and the activity was facilitated by the faculty mentor. The students selected three best plans amongst the total 8 plans. In the second week, for the selected three plans, the AutoCAD drawings were prepared combinedly by the team along with interior details. The team presented their plan and elevation that include underground drainage, water supply, electricity plans. During the entire activity faculty mentor facilitated the process. The finalized typical plan of the residential building of one group is presented in Figures 2 to 4.

Table 6: Presentation Steps of Cycle-iv

Steps	Particulars	Details
1	Learning outcomes	• To prepare measurement sheet of various quantities of all components. • Prepare abstract table and estimate the total cost of building. • To calculate the materials and labour required. • Prepare the Schedule of work and estimate the probable completion period using Network analysis (CPM/PERT) • Prepare the working drawings for construction
2	Problem and Appropriate Demand	• It is required to compute the material quantities • Estimate the total cost of the building • The labour required is to be estimated • Schedule of work is to be prepared • Working drawing shall be prepared
3	Resources to be collected	• Schedule of rates from the Public Works Department • MS Project software
	Prior Knowledge	• Quantity Surveying • Network Analysis • Knowledge of MS Project [**P4**]
4	Solution Guidelines	• Each team member shall calculate the quantities and compute total cost of building [**P3**] • Computation of labour requirement. • Schedule of work shall be prepared by the whole team [**P5**] • Working drawings shall be prepared by the whole team

Table 7: Requirements and Limitations of Client

Requirements:
- Three Bed Rooms out of which One shall be Master Bed Room
- Kitchen – Open Type
- Dining Hall
- Hall
- Verandah
- Pooja Hall
- Common Toilet
- Internal Staircase

Limitations:
- Facilities can be taken to First Floor, if required Circulation/Passage area shall be minimum

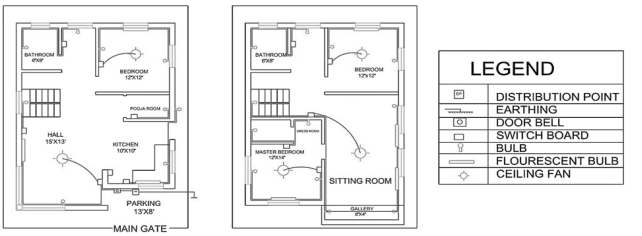


Fig. 3 : Plan indicating electrical layout

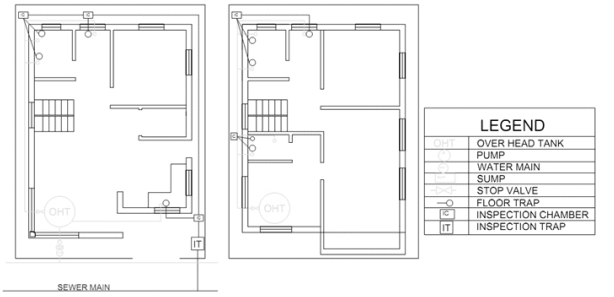


Fig. 4 : Plan indicating underground drainage and water supply lines

The learning outcome of cycle-1 "To prepare the plan of a residential building for a client as per the site condition and requirements" was measured through the feedback from the clients. The clients expressed their satisfaction of students' learning and understanding from the drawings. They also appreciated the implementation of PBL activity.

7. Students Feedback

The feedback was collected from the students on the 12 questions matrix consisting of closed (Yes/No type – 8 numbers) and open ended (brief descriptive – 4 numbers) questions and given in Table-VIII. Initially, students did not show interest in the PBL concept, however, when the problem was presented in the same format as experienced in the professional practices, the students get motivated to work on the problem. The overall experience of the students was very satisfactory. The PBL activated is motivating the students towards self-driven learning, team interactions, exposure to practical situations and solving the problems.

8. Faculty Experience

The faculty members experienced the challenges of convincing the students, however, with the advantages of PBL and the attainment of various attributes they could motivate the students in taking up the activity. Further, the mentors also enjoyed working with students.

Table 8 : Feedback Questions and Responses

Q. No.	Question	Type of question	Response
1	Were you aware about PBL earlier to this activity?	Closed ended (Yes/No)	Yes – 10% No – 90%
2	Whether your facilitators equipped you about the PBL activity and its advantages?	Closed ended (Yes/No)	Yes – 100% No – 0
3	Did you get opportunity to apply your gathered knowledge (earlier semesters) or skills to the problem given to you which is very close to the Real world?	Closed ended (Yes/No)	Yes – 100% No – 0
4	Did you able to spend extra time on this PBL activity?	Closed ended (Yes/No)	Yes – 100% No – 0
5	If answer to Question 4 is yes, total how many hours?	Open ended	Average of 3 hours per day
6	Did you enjoy working on the problem? If so alone or team.	Open ended	Enjoyed individually as well as in teams
7	Did this PBL helped in improvement of Teamwork and Interpersonal Skills?	Closed ended (Yes/No)	Yes – 100% No – 0
8	Did you experience challenges that made you to work or study on your own? Were you able to find the solution to the challenge faced by you?	Open ended	Yes, I found solution on my own. (general)
9	Do you feel the PBL activity keeps your knowledge for a Long-Term that you can use in your future endeavors?	Closed ended (Yes/No)	Yes – 100% No – 0
10	Did this PBL activity helped you in sharing your knowledge or Skills?	Closed ended (Yes/No)	Yes – 100% No – 0
11	Did your experience of in this PBL motivated you for lifelong learning skills?	Closed ended (Yes/No)	Yes – 100% No – 0
12	Write about your Experience during the PBL activity and suggestions if any in a line or two.	Open ended	• It was a very nice experience. • Practical knowledge increased due to this activity. • It helped to overcome the drawbacks by putting efforts to improve on own. • PBL activity did help in sharing our thoughts and ideas and also learn some new skills. • Same activity can be extended to public buildings. • Ready to take next cycles.

9. Conclusions

Nevertheless, the crafting of PBL problem for engineering courses is challenging but it is fascinating. It is experienced that numerous authentic as well as realistic (few) problems can be framed. Further, the problems can be crafted of different durations and worked into number of phases. The students can take up the PBL activities and their experience is encouraging. The outcome of the activity is promising in addressing many graduate attributes, which otherwise difficult to address in conventional method of teaching. The student's reflections demonstrated the learning and skill improvements in them and giving overall development. The experience of the present study is similar to the other researchers those have implemented PBL on different scenarios.

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Enhancement of teaching learning process by Blended Teaching

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Abstract: The teaching-learning process is one of the most fun ways to learn for a lifetime of a learning experience and inner competence. Teaching provides a kind of opportunity to share free trade of information and ideas in a useful environment. Effective teaching should follow the strategic path of dealing with the main motto of student vision and innovation. Drawing on the concentration of students in the classroom is a great influence, which gives the image of a good class. The experiential-based learning approach relates the concept of teaching to industrial standards and applications, where the student gets to know why, where, and what to learn. Current and future generations of students are born in the technological age and are more passionate about utilizing web resources. The traditional blackboard teaching class seems passive and, in experiential that fails to grab the attention of millennials. Blended teaching (Flipped Classroom) can make the classroom dynamic and interactive. We have practiced some active learning techniques such as Flipped STAD, reciprocal teaching, and flipped classroom to make the classroom interactive and dynamic. This article discusses the experiences and barriers of blended teaching combined with classroom practices. This article will help the aspirants who are in thirst to adopt innovation in teaching

Keywords: Blended teaching, flipped classroom, reciprocal teaching, effective teaching, STAD

1. Introduction

It is a general tendency among the student community to experience boredom when there are no student engagement activities and it is quite difficult for the lecturer to teach a vast subject effectively without spending much time while conducting activities [1]. It is also seen that in conventional teaching practices students usually fail to solve more problems [2]. Flipped classroom models generally eliminate this problem, because students are made to solve numerical problems within the classroom and take away theoretical concepts as homework by which both the student and lecturer are benefitted [3]. Flipped classroom models are maybe normal flipped class and blended flipped class but are more flexible as the classroom can be converted to the regular conventional class whenever it is necessary [4]. This flexibility of the blended flipped classroom model

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makes it easy for implementation as well [5]. The research was conducted to assess the effectiveness of flipped classrooms (A classroom improvement activity) against traditional teaching techniques [6-8]. This mixed flipped classroom approach was applied to engineering students pursuing their degrees.

2. Background

In traditional blackboard teaching, the class will be passive and not student-centric, it is observed that blended teaching (flipped classroom) can make the classroom dynamic and interactive [9]. There should be a gradual improvement to shift the methodology of teaching [10]. Students' learning capacity, engagement, teamwork, and communication skills improve with blended instruction [11-12]. Some of the most significant elements to consider when implementing a blended method of instruction include

1. Practice on technology tools like Edmodo, Google classroom, TED-Ed, and Moodle, etc.
2. Set clear objectives and outcomes for each activity
3. Develop good content which enhances the skills of the students
4. Refine and improve the content and methods
5. Conduct some online quizzes, MCQ and take the feedback from the students
6. Gradually implement a flipped classroom
7. Take the feedback from students and faculty regularly

Collaborative Learning activities help slow learners improve their learning abilities. This grouping of students is based on rank, gender, and problem-solving abilities and they participate in activities that increase student engagement [13-15].

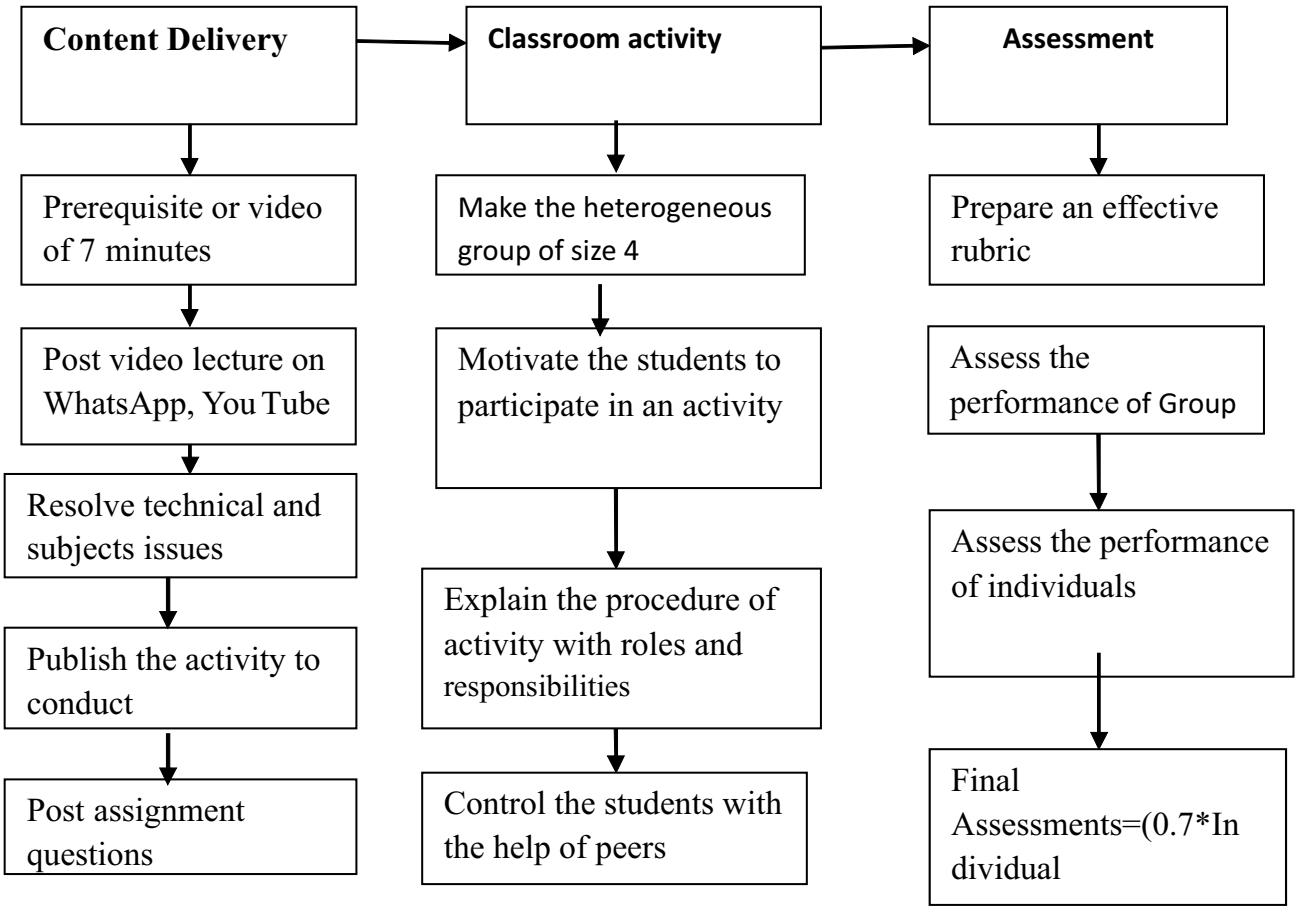


Fig. 1: Flow diagram for the teaching-learning process

3. Methodology

The teaching-learning process is divided into three phases: 1. Content delivery 2. Classroom activity 3. Assessment. The flow diagram for the teaching-learning process is given in figure 1. The content delivery includes provision of pre-lecture video, post lecture video, assignment questions, solutions to technical issues. The efficiency of the content delivery can be analyzed by conducting classroom activity, the detailed analysis about classroom activity is discussed in the succeeding modules. The outcome of the activity can be measured through different levels of assessments. The assessment details and formation of rubrics are detailed in the modules that are cited in the below sections of this article.

3. Blended Teaching Techniques:

3.1Flipped classroom:

a) Scope: Flipped classroom and its practices

Flipped classroom instructional model relates to the concept of gaining prior knowledge about the concepts that are to be discussed in the upcoming class. Flipped classroom module is giving the sense that, usually students will learn in class and compute assignments or exercises at home [16]. The term flip stands in the point that, students will learn at home and practices discussions, exercises group discussion in class.

b) Design and Practice

The effectiveness of the flipped classroom can be experienced by selecting the suitable appropriate for the practice. The pre-learning module is identified and, the users are facilitated through a pre-knowledge gaining approach. The students have their responsibility in gaining knowledge [17] from the identified sources. The users are segregated into smaller groups in real-time. The users experience an active mode of learning. The instructors can facilitate the students suitably by introducing small group activities among them. The flipped classroom encourages a collaborative learning approach and ensures a diversified learning environment.

c) Effectiveness of the activity

The flipped classroom encourages a collaborative learning approach and ensures a diversified learning environment. The traditional method of teaching provides knowledge in a non-experiential manner. In contradiction, the flipped classroom provides knowledge so that, students can realize the concept, its applications, and the purpose of the theme. In short, flipped classroom module claims its role as an experiential methodology for the users to learn effectively. For analysis, an assessment was conducted using the traditional method and flipped classroom approach. Fig 2 shows the outcomes for the flipped classroom, the analysis reveals that there is a substantial rise in the learning rate as compared to the traditional delivery method.

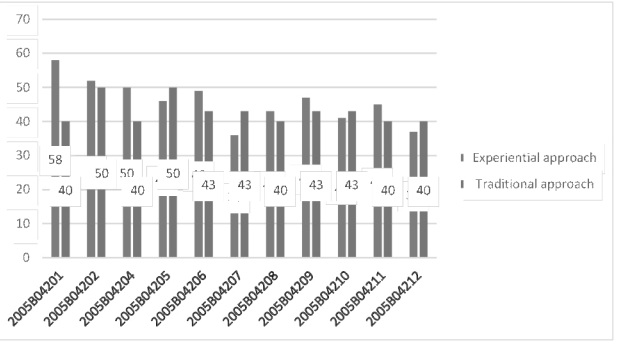


Fig 2 : Flipped classroom and its outcomes

3.2 Classroom Activities & Reflections:

3.2.1 Collaborative Learning

Section 3.1 discussed the flipped classroom approach and its effectiveness. The flipped classroom module depends on several tools and methodologies for its assessment. This section briefs out some interesting activities that support flipped classroom implementation among user groups.

a) Implementation Details

Students- Teams- Achievement-Division (STAD)

The Students- Teams- Achievement-Division (STAD) is a group activity that can be used as an assessment tool during flipped classroom practices conducted in the classroom. This method is suitable for shared learning levels. The students are placed in small groups or teams. For analysis, consider a group of 60 students is segregated into batches. The batch size of 4 will lead to the formation of 15 successful groups [18-19]. Students are grouped based on the following criteria:1. Based on their learning style 2. Based on Gender.

The importance of furnishing such criteria are

Criteria 1:Equally motivates different learning levels.

Criteria 2: Encourages learning without bias.

Flipped classroom-based STAD (FSTAD) and its flow

This article focuses on STAD in correlation with a flipped classroom, Figure 3 shows Flipped classroom-based STAD and its flow is discussed in this section. In normal STAD practice, the students are segregated into small groups and, a concept or topic is discussed in the class before the discussion. In a flipped classroom-based STAD, the concept is delivered in the form of the virtual source using web resources or prerecorded video shared to students using any of the Learning Management System (LMS). The students will come to class with prior knowledge concerning the topic of interest. The students are segregated into small groups and, the group discussion is implicated among the groups. The group discussion is felicitated by the corresponding instructor to ensure equal learning among the existing group. A quiz can be initiated after observation of the level of outcomes from different groups. The quiz can be taken by the students on an individual basis. The individual marks are cumulatively added and assessed on a group basis. The team with the highest marks was rewarded.

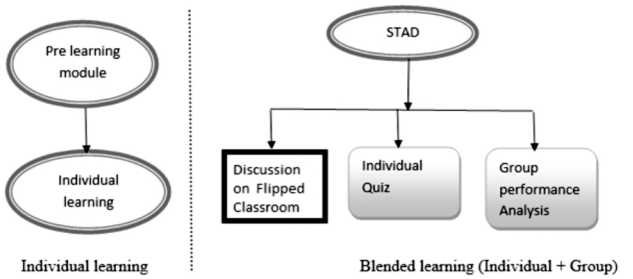


Fig. 3 : Flipped classroom-based STAD

Level of assessment for FSTAD

FSTAD allows students assessment in two ways: 1. Formative assessment 2. Summative assessment for individuals and groups.

- Formative assessment for an individual includes observation by the instructor of an individual, interim quiz.
- Summative assessment for the individual includes individual reports and Quiz results.
- Formative assessment for the group includes progress presentation and group quiz
- Summative assessment for the group includes the overall achievement of the team.

3.3 Reciprocal teaching

The important claim in this article, we can use any number of assessment tools at the reader's convenience. There are so many web resources available nowadays that allow the readers to select the tools according to their convenience. The important key is the tools are designed in the view of a common base. Consider the reciprocal teaching that relates flipped classroom, STAD in their design. The practicing methodology looks very close with a minute difference. The readers can compromise that, anyone can use any tools, but expertizing in one tool makes the things realizable irrespective of the tools and their design.

For analysis, consider the activity reciprocal teaching in correlation with flipped classroom approach. Fig 4. shows the design flow for Flipping and reciprocal teaching.

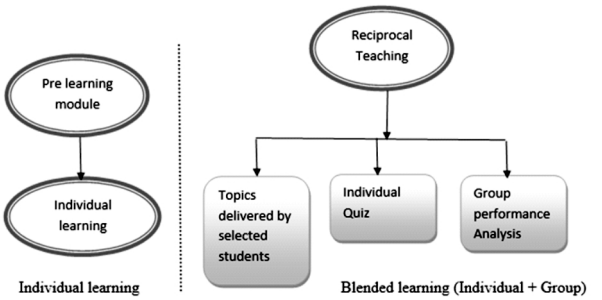


Fig. 4 : Flipped classroom-based Reciprocal Teaching

Fig 4 is a circular reference of Fig 3, it is evident from the diagram that, the flow is similar with a small modification in the design. The design and practice of modified reciprocal are discussed below.

1. Flipped classroom task is initiated among students.

2. Students gain prior knowledge about the topic of interest individuals

3. Students are grouped with minimum and comfortable batch sizes depending on the class size.

4. A set of students will demonstrate the concepts and workouts gained by themselves through virtual

learning.

5. Remaining steps and methods are similar to FSTAD (circular reference)

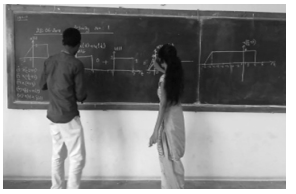
Constraints while implementing the activities

There is no free lunch, each activity and practice has its advantages and disadvantages. The most important constraint is lack of resources, some rural students do not have web resources due to their poor economic backgrounds. These students are the main victims while practicing any activities that relate to web activities. These students are forcibly behaving as free riders. Motivating such students is an important aspect while practicing any outcome-based approach. Less intention to those students will make them a strong protestor for activity-based learning. The resolution can be obtained by practicing a blended approach, a special contact class can be conducted apart from the regular teaching hours and the topic of interest and related materials are shared with those students on a manual basis. Another approach the students can be counseled to complete their activities on their campus itself. In this pandemic situation, it is very hard to convince and address the students from rural backgrounds. Research is still going on to meet out the needs of rural students without any constraints. This article is also having constraints in the successful implication of blended teaching when the point of complete remote learning is the mandatory source of learning.

Evaluation of the success of activity:

In this pandemic situation, blended teaching is the only hope for the education platform. Keeping this point, as a point of hope, let us analyze the trends for the activities that, we analyze in the earlier sections. Figure 5 shows blended teaching Activity & reflections. The important observations while implementing the teaching modules and activities are 1. Active involvement of students 2. Collaborative learning skills and practices 3. Sustainability in solving problems 4. Development in personality, improvement in communication 5. Self-building of confidence to face the real world.





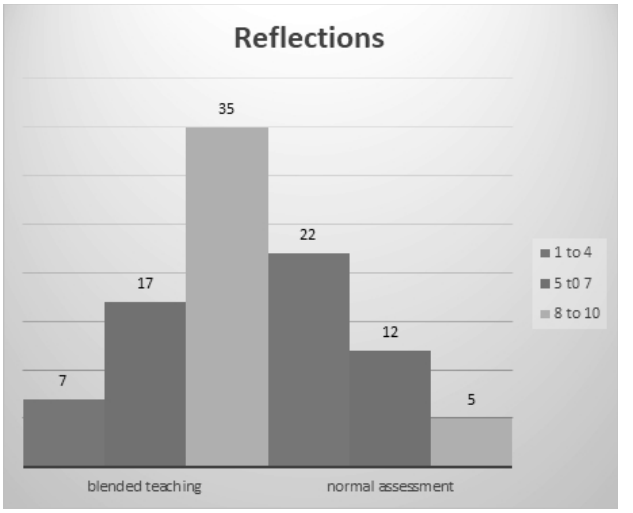


Fig. 5: Blended teaching Activity & reflections

Table 1: Blended teaching Activity summary

Scores	Blended Teaching	Normal teaching
Number of students attended : 49 students / 39 students		
1 to 4	**5**	**22**
5 to 7	**17**	**12**
8 to 10	**35**	**2**

Table 1 gives the reflections of blended teaching; reciprocal teaching observations are presented here for analysis. The Group of 20 students is selected and the topics are demonstrated in different methodology until the entire class gets satisfied with the topic of interest. The table reveals that there is a considerable increase in the learning rate, such that, the average and best score seems remarkable. The students' attendance also has attained certain improvement.

4. Effective assessment:

4.1 Rubric for Individual students:

Table 2 : Rubric for Individual assessment

Parameter	Outstanding (5 marks)	Good 4Marks)	Average (3 marks)	Poor (1 mark)
Participating in discussion (formative)	Enthusiastically participated with good outcomes	Actively participated	Participated some times	Rarely participated
Helping team members in solving problems (formative)	Helping team members and solved all the issues	Helping team members and solved some issues	Tried to help other members	Passive
Quiz performance (summative)	Every correct answer give 1 mark of a maximum of up to 5 marks			

Rubric for Group:

Table 3: Rubric for Group assessment

Parameter	Outstanding (5 marks)	Good (4 Marks)	Average (3 marks)	Poor (1 mark)
Meaningful discussion group (Formative)	The discussion gives highly relevant information which solves the problems	The discussion gives more relevant information	Discussion is mixed of relevant information and irrelevant	Discussion is irrelevant
Achievement of the final task (summative)	Achieve the desired output with outcomes	Achieve the desired output	Achieve the output with some errors	Not achieve the desired output
Quiz score by group(summative)	Every Correct answer give 1 mark of a maximum of up to 5 marks			

Table 4 : Assessment of individual performance

Individual score: Max Marks: 20

	Assessment			
	Group	**Score**	**Individual performed less than median score Yes/No**	**One most important reason for individual performance**
1	1	10	No	He is good at the subject
2	1	12	No	Good in calculations
….	…	….	….	……
60	15	13	No	Good at creativity

Table 5 : Assessment of group performance

Team score: Max Marks: 20

Team No.	No. of Students	Team Score (Median Score)	The team performed less than the median score (Yes/No)	One most Imp. Reason for Teams performance
1	4	12	No	He is good at the subject
2	4	11	No	Good in calculations
3	4	10	No	Good in verbal
4	4	12	No	Excellent in subject
5	4	9	Yes	Poor in verbal
6	4	10	No	Well in verbal
7	4	11	No	He is good at the subject
8	4	9.5	Yes	He is poor at the subject
9	4	11.5	No	Good in calculations
10	4	12.5	No	Good in verbal
11	4	13	No	Excellent in subject
12	4	10.5	No	He is good at the subject
13	4	11.5	No	Good at verbal skills
14	4	10.5	No	Good at calculations
15	4	9.5	Yes	Very poor at creativity

Conclusion & Future scope:

To implement a blended model of teaching, an intensive study was done to showcase the methodologies and techniques for implementing effective blended teaching. This article is prepared to identify and analyze different strategies involved in the blended teaching approach. Flipped classroom concept is taken for analysis, in which students will learn the concept on self -learning basis. The classroom becomes a collaborative space, in which, students can work collaboratively and realize things in an experiential approach. This enables an active learning culture in a normal classroom. However, the important barrier in the implication of flipped classrooms is no voice attendees. The students with a lack of web resources are the important aspirants to drop out from the activity practices, even though they have good learning skills. The web resources make the students stay away from this experiential approach. The teaching community needs to provide manual support, so that, to enhance uniformity in learning. The effectiveness of blended teaching needs proper training to instructors as well, before implementing any practices. The result and discussion prove that blended teaching will improvise the students' abilities in terms of critical thinking, applying knowledge, and lifelong learning. The assessment results show a fair growth in the learning aspects of the students in comparison with the normal teaching-based assessment. The blended teaching will provide an unbiased and active learning base among students. The teachers, in turn, will get instant feedback about the student caliber and their approach towards learning.

In short, the blended teaching will make the pedagogy student centric and, it will help the students to reach their milestones.

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Blended Learning Approach to Engineering Education: Students' Perceptions on Learning Experience and Effectiveness

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Abstract: The impact study conducted in a residential engineering university in rural India evaluated the effect of blended learning (BL) on the Engineering students' learning experience and effectiveness. Data collected through the post-course student survey and students' performance scores in the end-of-semester examination helped in understanding students' perceptions on blended learning and analysing blended learning effectiveness. Though the t-test results of achievement comparison between BL students and non-BL students' were mixed; the perceptions of students leaned in favour of blended learning. This paper presents the Engineering students' perceptions towards blended learning experience and effectiveness of their teachers' blended instructional practices and the correlation between students' blended learning satisfaction and achievement.

Keywords: Blending learning, Course design, Engineering education, Learning management system, Impact study, Moodle

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1. Introduction

In India, 3,500 institutions are disseminating engineering education. Barring the Indian Institutes of Technology (IITs), other Engineering Institutes are struggling with a critical shortage of qualified and quality teachers, low enrolment, lower placements, and low employability, resulting in a dearth of quality professionals and poor employability of engineering graduates (Cutrell et al., 2015; AICTE, 2019). In order to improve the situation, the report of the AICTE's Committee for "Preparing Short & Medium Term Perspective Plan for Engineering Education in India" (2019) recommends technology interventions, innovations in pedagogy, such as blending MOOCs with core and optional curricula, providing individual learning path for each student. Though, Indian Engineering colleges have been using National Programme on Technology Enhanced Learning (NPTEL) videos in teaching, clear implementation guidelines are not provided to adopt curriculum-integrated approach nor there have been any blended learning impact studies to suggest evidence-based blended learning practice that can improve learning outcomes in engineering education in India (Cutrell et al., 2015). To address the above-mentioned issues, Commonwealth of Learning (COL, n. d.) through its "Policy–Technology–Capacity" advocacy, provided the needed support to Rajiv Gandhi University of Knowledge Technologies (RGUKT).

The study "Impact of Technology-Enabled Learning Implementation at Rajiv Gandhi University of Knowledge Technologies" (Indira, 2019) evaluated the impact of blended learning (BL) on the Engineering students' learning experience and learning outcomes and their teachers' instructional strategies. This paper presents the Engineering students' perceptions towards blended learning experience and effectiveness of their teachers' blended course design and instructional practices and the correlation between students' blended learning satisfaction and achievement.

2. Background

The Government of Andhra Pradesh established the Rajiv Gandhi University of Knowledge Technologies (RGUKT) in 2008 for providing Engineering education opportunities for the deprived rural youths through the 6-year integrated Engineering programme – 2-Year PUC / Pre University Course and 4-Year B. Tech. / Bachelor of Technology (undergraduate) from four campuses, namely, Nuzvid, RK Valley, Srikakulam and Ongole. The university provides each student and teacher with a laptop and broadband connectivity for officials, teachers, learners, researchers and visitors.

The University's ICT-based pedagogy provided students with access to video lectures, Open Educational Resources (OER) and other eContent through the local content servers, but not through the Learning Management System for anytime and anywhere access. Most of the teachers use word processing, spreadsheets, presentations, email, search engines and databases. However, they lack in advanced digital content creations skills such as graphics editing, multimedia authoring, digital audio, video editing, Web design and LMS skills (Venkaiah, 2017). In order to adopt a blended learning approach to strengthen the existing ICT- based pedagogy and improve the quality of student-content, student-student and student-teacher interaction and students' learning outcomes, RGUKT partnered with Commonwealth of Learning (COL).COL's support helped the RGUKT in: (i) conducting a baseline study on TEL; (ii) developing a TEL policy for blending appropriate technologies with teaching-learning; (iii) building capacity among the teachers to design, develop and deliver blended learning courses through Moodle; and (iv)undertaking an impact study.

3. Review of Literature

Blended learning, a combination of traditional F2F learning systems and distributed learning systems emphasises the central role of computer-based technologies in teaching- learning (Graham, 2006). As a formal education programme, blended learning combines online with face-to-face teaching-learning in a pedagogically valuable way to increase student engagement in the learning process and to improve student control over the time, place, pace and path of learning (Kenney & Newcombe, 2011; Christensen, Horn and Staker, 2013).

Blended learning as a techno-pedagogical innovation (Chafiq N., Housni M., Moussetad M., 2019) facilitates teachers create an enabling digital learning environment and design learning experience through the organic integration of thoughtfully selected face-to-face and online approaches (Vaughan, Garrison, & Cleveland, 2013). Students learning experience in a blended learning environment largely depends on (i) pedagogical richness of a blended course that improves student engagement in autonomous, co-operative, collaborative, constructive and interactive learning and (ii) technological ease that facilitates convenient and flexible learning opportunities.

Quality, reliability and availability of the system used and the ease at which students access and navigate the LMS, its tools and course content and technology orientation play a major role in blended learning success (Piccoli, Ahmad, & Ives, 2001; Kintu, Zhu & Kagambe, 2017; Hofmann, 2014). Convenience, efficient use of time, flexibility, course content, learner interface, reflection, interaction and relationships with peers and teachers, collaboration and feedback, combined synchronous and asynchronous communication tended to report more positive effect on blended student perception and satisfaction (Tobin, 1998; Chang & Fisher, 2003; Shee & Wang, 2008; U.S. Department of Education, 2010). Finding appropriate technology to create an enabling blended learning environment and identifying tools to engage students in learning interactions with the content, instructor and peers are vital to have a positive impact on student achievement.

4. Blended Learning Environment

Creating a blended learning environment

necessitates providing access to technology; adequate and timely support and building technological and pedagogical capacity amongst the staff (Cook, Giardina, 2011). A blended learning environment necessitates teachers to assume the role of an instructional and/or learning designer. At RGUKT, a blended learning environment was created using Moodle1 (Modular Object-Oriented Dynamic Learning Environment), an open source LMS (Learning Management System).

Moodle hosted on the RGUKT local server2 facilitated the teachers to blend F2F teaching with online learning; create flexible learning environment; share and manage content in multiple media; create activities and assessments; grade students' performance and provide feedback; communicate online and offline learning events with students; and engage students in collaborative and constructive learning tasks (Indira, 2015). Eighteen Moodle-enabled blended courses were offered to the Pre-University Course (PUC) and Engineering undergraduate students during the January– April 2018 semester.

The two capacity building workshops on blended course design, Moodle functionality, open educational resources (OER), screen-casting videos, blended course development etc. enabled the RGUKT teachers to:

- redesign their courses using the backward design (Wiggins & McTighe, 2002) and/or constructive alignment (Biggs, 2003) approach;
- structure the online course week-wise or unit-wise;
- write course and unit learning outcomes;
- self-record the course introductory video and Face/Flip (Ruffini, n.d.) videos using Screencast-O-Matic3; publish on YouTube; and embed in the Moodle course in order to orient students towards the blended environment, provide online learning support and have pedagogical effectiveness on learning (Garner, 2008; Pang, 2009);
- create assessments, such as file submission and video-based assignments, such as ANSYS/Autodesk Inventor, professional software- based assignments and self-assessment quizzes for creating a test series environment;
- engage students in interaction through activities, such as forums and chat;
- promote leaner-content interaction by creating interactive videos using the H5P plugin4 to increase learner engagement and enhance learner control over the content and process (Zhang, 2005);
- cover and share more materials (Karabulut-Ilgu, Jaramillo Cherrez & Jahren, 2018);
- share and/or crate learning resources in a variety of media, including Khan Academy videos, animated videos, video tutorials (on ANSYS 2D Modelling, ANSYS 3D Modelling, ANSYS Meshing) and open educational resources (OER), such as NPTEL5 and PhET6 Interactive Simulations;
- track students' learning progress and course participation;

[5] National Programme on Technology Enhanced Learning, a project funded by the Ministry of HRD offers multimedia- based material and courses for basic undergraduate Science and Engineering courses. https://nptel.ac.in/

[6] PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. Journal of Engineering Education Transformations, Volume , No, Month 2015, ISSN 2349-2473, eISSN 2394-1707

- grade students' performance and provide feedback;
- communicate with and send bulk and individual messages and alerts to students through Moodle course and Moodle mobile app; and
- take maximum advantage of the benefits of digital delivery (Bailey, 2018).

90–100% of the BL teachers valued that the capacity- building workshops helped them in understanding and integrating Moodle functionality with the blended course design and in developing online course as per the course design. They also noted that the COL Facilitator's post- workshop mentoring through the WhatsApp group, e-mail and phone had helped them throughout their blended teaching-

learning journey, i.e., from blended course design through evaluation.

5. Research Questions

The study formulated the following research questions to investigate the impact of blended learning on students' learning experience and effectiveness.

- How do learners perceive the effectiveness of the blended learning environment in their course of study?
- How does teacher practice affect student perception of blended learning courses?
- How do students perceive their teachers' practice and behaviour in a blended learning environment?
- How do perceptions of learning in blended courses relate to achievement?

6. Research Method

The study collected data through a survey on students' perceptions and satisfaction about their blended learning experience and effectiveness and students' performance data in the end-of-semester examinations. To analyse the differences in students' academic achievement, the students' scores in the January–April 2018 semester BL courses were compared with the scores of students in the January–April semesters of 2016 and 2017 taught by the same faculty. The intention was to compare the blended courses with the traditional courses offered by the same teacher who had followed the same curriculum assuming that the students in different batches had similar characteristics.

A. Sample

The study sample included the 1632 blended learning students from 18 blended learning courses developed in Chemistry, Chemical Engineering, Computer Science, Civil Engineering, Electronics and Communications Engineering, Humanities and Mechanical Engineering disciplines. The student sample was not randomized, as the research was limited to the 18 blended learning courses. Therefore, there may be a self-selection bias in the results of this study.

B. Survey Instrument

The student post-course survey questionnaire was developed by adapting some questions from Owston, York, & Murtha (2013). The instrument comprised of demographic questions; questions on the blended learning courses delivered; student evaluation of the quality of blended course teaching; and on overall blended learning satisfaction. The students rated their perception and satisfaction on a five-point scale of either “Excellent” (5) to “Poor” (1) or “Strongly Agree” (5) to “Strongly Disagree” (1). The reliability and internal consistency of the survey instrument was measured using Cronbach's (1951) alpha coefficient. The values ranged from 0.89 to 0.80 exceeded the accepted level of 0.70.

A. Data Analysis

The quantitative data obtained from students' online survey responses about blended learning effectiveness and satisfaction, and from students' end-of-semester results, were analysed through descriptive and inferential statistics. The two-sample t-test assuming unequal variances was used to determine the relationship between students' education level and their perception of blended teaching practices. ANOVA tests helped in comparing students' level of satisfaction with their achievement, among and between groups.

7. Findings

Out of 1,632 blended learning students (See Table 1), 730 (44.73%) were male, whereas 902 (55.27%) were female. 909 (55.7%) students were from

Table 1: Demographic and academic profile of respondents

Programme of Study & Gender	RGUKT Nuzvid Campus	RGUKT RK Valley Campus	Total
B. Tech.	598 (54%)	311 (60%)	909
Female	385 (64%)	80 (26%)	465
Male	213 (36%)	231 (74%)	444
PUC	514 (46%)	209 (40%)	723
Female	309 (60%)	128 (61%)	437
Male	205 (40%)	81 (39%)	286
Total	1112 (68%)	520 (32%)	1632

Bachelor of Technology /B. Tech. (undergraduate) programme and 723 (44.3%) were from the Pre University Course / PUC.

A. Effectiveness of Blended-Learning Environment

For measuring blended learning effectiveness, various studies used performance related indicators, such as learners' grades comparison, course completion and their success (Garrison & Kanuka, 2004; Kenney & Newcombe, 2011; Renner, Laumer & Weitzel, 2014). However, in addition to performance, this study looked into the other co-curricular outcomes, namely, improved digital literacy, flexibility, time management, learning experience that complement their blended learning experience. The first research question "How do learners describe the effectiveness of the blended-learning environment in their course of study?" sought students' perceptions on the afore-mentioned indicators.81% to 91% students had positive perception on the overall effectiveness of blended learning environment. 84.8% students perceived that blended learning improved their digital literacy. 91.16% agreed that information technology helped them to learn and 86.27% appreciated that the LMS-enabled multimedia resources enriched their learning experience. 83.45% valued that interacting and communicating synchronously and asynchronously with students and faculty improved their learning and 81.42% agreed that blended learning improved their time management skills. 85.51% perceived to have greater convenience and flexibility to regulate their pace of study of course materials and their participation in activities. 85.21% were satisfied with the use of Moodle mobile app for viewing / reading learning resources; interacting with faculty and peers; and submitting assignments and quizzes. 82.16% agreed that blended learning improved their performance in mid-semester examinations.

From the data, it was evident that students appreciate a blended learning environment that provides greater access to knowledge, greater engagement in interaction with peers and teachers; greater convenience and flexibility; a higher level of autonomy to regulate their own study of course materials and to set the pace of their participation in online discussions and synchronous and asynchronous communication. (Chang & Fisher, 2003; Shee & Wang, 2008; Tobin, 1998; U.S. Department of Education, 2010; Larsen, 2012; Owston, York & Murtha, 2013).

A further analysis was made to ascertain whether gender and level of study make a difference in perception of the effectiveness of the BL environment.

The independent t-test results conducted on all aspects of BL effectiveness suggest that there is a difference in the perceptions of male and female students about BL effectiveness. Male students had more positive perceptions than female students.

B. Student Perceptions of Teacher Course Design and Delivery Practices

Research question 2 and 3 sought the blended learning students' perceptions on their teacher's blended course design and delivery practices. The second research question "How does teacher practice affect student perception of blended learning courses?" measured students' perception of teachers' blended course design and delivery.

A blended learning approach necessitates teachers to rethink course design, development and delivery practices to help students understand the course overview, learning objectives, assessment and evaluation, instructional materials, activities, course technology, learner interactions, learner support, accessibility and usability. Teachers' attitudes and beliefs, their willingness to try new teaching methods, and their use of a balanced mixture of synchronous and asynchronous communication are all key factors in a successful BL course (Alammary, Carbone & Sheard, 2015; Owston & York, 2018; Quality Matters, n.d.).

The students' perception mean to the various questions ranging between 3.84 and 4.06 indicate that students had a highly positive perception towards blended course design. 60-70% of the students' perceived their teachers as effective course designers and deliverers. They were good at describing the course, its learning objectives, activities and assignments (mean=3.92), communicating information (mean=3.91) and expected performance in activities (mean=3.89), overall organization of the course (mean=4.06), making learning resources available in multimedia (mean=3.9), blending face-to-face with online learning (mean=3.89), maintaining the pace of the course (mean=3.84) made their learning effective.

ANOVA test was run to ascertain whether students' perceptions differed between blended courses. The

Table 2: Comparing students' perceptions among blended courses (ANOVA)

Source of Variation	*SS*	*df*	*MS*	*F*	*p-value*	*F-crit.*
Between groups	8.13	17	0.48	35.08	3.81E -36	1.718 165
Within groups	1.47	108	0.014			
Total	9.60	125				

results in Table 2 with F value more than the F-critical value and a p value less than 0.05 indicate that the students' perceptions of the blended course design statistically differed among the various blended courses.

To seek answers to the third research question "How do students perceive their teachers' practices and behaviour in a blended-learning environment?", students were asked to rate their teachers' blended teaching practice and interest in students' learning; tracking of their learning progress; alerting students; providing orientation and feedback; and stimulating students' interest.

Students response to the 'overall experience of the course' (mean= 4.01) indicate that students had a highly positive perception on their teachers' blended teaching practice and behaviour. 60%-70% of the respondents perceived that their Faculty showed interest in their learning (mean=4.2), stimulated their interest in blended course (mean=4.06), tracked their learning progress and sent alerts (mean= 4.14), provided feedback on their performance (mean=3.98) and orientation (mean= 4.03) and were available in-class and online (mean=4.03) for needed support. All BL teachers provided in-class orientation to the students and some teachers even engaged student ambassadors for promoting blended learning.

C. Students' perception on teachers' blended teaching practice

A blended teaching-learning approach requires teachers to rethink their course design to enable students understand the course overview, learning objectives, assessment and measurement, instructional materials, activities, course technology, learner interactions, learner support, accessibility and usability. Teachers' attitudes and beliefs, their willingness to try new teaching methods, and their use of a balanced mixture of synchronous and asynchronous communication are all key factors in a successful BL course (Alammary, Sheard & Carbone, 2014; Owston & York, 2018; Quality Matters, n.d.). This research question "How does teacher practice affect students' perception of blended- learning courses?" adapted some of these criteria to ascertain students' perception of teachers' blended learning course design and delivery practices 60–70% of the students perceived their teachers as effective at describing the course, its learning objectives, activities and assignments (mean = 3.92), communicating information (mean = 3.91) and expected performance in activities (mean = 3.89), organising the course overall (mean = 4.06), making learning resources available in multimedia formats (mean = 3.9), blending F2F with online learning (mean = 3.89) and maintaining the pace of the course (mean = 3.84). Further analysis of the data helped to ascertain differences in perceptions between PUC and B. Tech. students.

A t-test was administered with a significance level of 0.05 to find out whether the students' perception of blended teaching practice differed between PUC and B. Tech. students. The p-value in Table 3 indicates there was no significant difference between PUC and B. Tech. students' perceptions of the BL course design and teaching practices except for one: the teacher's communication of ideas and information in the course.

Table 3 : Relationship between education level and students' perception of blended teaching practices

Dimensions of blended teaching practice	**t**	**p**
Description of course objectives, learning activities and assignments in the online course	**1.90**	**0.06***
Communication of ideas and information in the course	**2.04**	**0.04**
Expression of expectations for performance (e.g., online forums, assignments and quizzes) in the course	**0.83**	**0.41***
The instructor's overall organisation of the course	**– 0.78**	**0.44***
Online learning resources made available within the LMS	**– 0.49**	**0.63***
Continuity between F2F class and online learning	**0.27**	**0.78***
Pace of the course	**1.48**	**0.14**

* p = < 0.05

D. Achievement in Blended Courses

Similar to other impact studies, the study considered student grades obtained and/or improved as an indicator to establish the effectiveness of blended learning. The t test was used to measure "How is the learning achievement in blended learning course different from other courses in the university?" To analyse the differences in students' academic achievement, the scores of the 2018 January–April semester BL students were compared with the scores of students in the January–April semesters of 2016 and 2017 taught by the same faculty with the same curriculum.

The comparison of mean achievement scores of BL students and Non-BL students showed a mixed result. The following chart (Fig. 1) indicates that there was an improvement in students' achievement in nine courses and no improvement in nine courses.

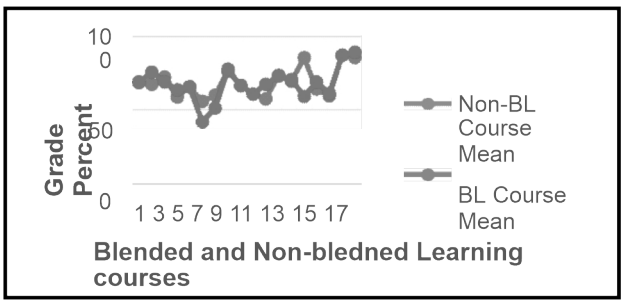


Fig. 1: Blended learning courses and non-blended learning courses

The *t* test results in Table 4 indicate that the difference in grades were statistically significant in nine courses (50%): Chemistry (P2S2), Computer Organisation & Architecture, Design of Machine Elements II, Engineering Mathematics 1, Foundation Engineering, Heat Transfer Chemical Engineering, Mass Transfer Operations-II, Natural Language Processing, and Telugu PUC P2S2 and no significant difference in the other nine courses (50%).

Further analysis of blended course design and delivery of the 18 blended courses helped in understanding the reasons for negative or zero impact of blended learning on students'achievement and identify the difference (if any) in the course design, content sharing, structured activities and course-delivery patterns that optimised student engagement (Dziuban, Moskal & Hartman, 2005; Garrison & Vaughan, 2008; Owston & York, 2018).

No major difference in the organisation and structure of the Moodle courses was detected, as all the courses had an introductory video/overview in text presenting the learning outcomes, as well as resources, activities and unit or weekly assessments. The difference lied in the type of learning resources shared and student engagement in activities and assessments. The teachers of nine impacted blended courses shared or created multimedia-enriched resources and engaged students in active and interactive learning through forum discussions, chat interactions, interactive videos and by providing solutions to the quiz questions and creating competitive exam / a test series environment similar to the GATE (Graduate Aptitude Test in Engineering) preparation. Aravinthan and Aravinthan, 2010 examined the effectiveness of Moodle-enabled self-assessment quizzes in two Engineering courses and found a strong correlation between students who attempted the quizzes and their final grades.

On the other hand, the teachers of nine non-impacted courses failed in providing an appropriate mix of content richness, interaction, and engagement (Zhang, 2005). In the 9 non- impact blended courses, the deficiencies that resulted in negative or zero

Table 4: Blended Learning students and non-blended learning students' grades mean comparison

Blended Courses	*t*	*p* value*
Chemistry (P2S2)	3.76	0.00
Computer Organisation & Architecture	1.96	0.00
English (P2S2)	1.97	0.1
Heat Transfer Chemical Engineering	1.98	0.00
Introduction to Artificial Intelligence	1.65	0.4
Natural Language Processing	1.98	0.00
Signals & Systems	1.96	0.09
Telugu (P2S2)	1.97	0.72
Foundation Engineering	1.97	0.05
Telugu (P1S2)	2.00E+00	2E-07
Chemistry (P1S2)	1.97	0.79
Computational Fluid Dynamics	2.06	0.41
Data Mining	1.97	0.94
Design of Machine Elements II	2.00E+00	6E-07
Engineering Mathematics 1	1.96	0.00
Environmental Engineering	1.98	0.99
Heat Transfer Mechanical Engineering	1.97	0.83
Mass Transfer Operations-II	2.18	0.00

impact on students' performance include: (i) 70-80% of the learning resources were text-based files rather than multimedia, (ii) fewer activities, (iii) no moderation and interaction in the forums, (iv) no or fewer assignment submissions and quiz attempts. The number of assignment submissions and quiz attempts were 90–100% in the first month but dropped to 10–0%, as the online assessments were not considered part of evaluation, and the faculty did not grade them or provide prompt feedback. The teachers failed to engage students with online resources and activities or to motivate students to do the online assignments and provide adequate opportunity and support for student engagement through forums, thus resulted in lower proficiency and academic performance (McGee and Reis, 2012; Montgomery et al., 2015; Wichadee, 2018). As reported by the RGUKT BL teachers, they were unresponsive to students' assignment submission due to time constraints and lack of a supportive policy for including online assessments in the university's evaluation scheme.

E. Perceptions of Learning and Achievement

To derive answer to the fifth research question "How do perceptions of learning in blended courses relate to achievement?" students' perceptions about their blended learning experience with multimedia content, and online communication and interaction with faculty and students were correlated with their grades. The results indicated that there was no significant relationship between students' perceptions of learning and grades. The regression analysis with grades as the dependent variable and satisfaction construct variables as the independent variables (Table 5) indicate that the relationship between students' perception of blended learning and grades was not statistically significant, as the p values ranged between 0.21 and 0.44 and greater than the alpha (0.05) value.

Table 5: Regression analysis of student perceptions of blended learning and achievement

Student perceptions	*r*	*F*	*p*
Multimedia resources on LMS enriched my learning experience	0.31	1.72	0.21
Communicating online with students and faculty improved my learning	0.20	0.64	0.44
Blended learning improved my performance in mid-semester exams	0.30	1.57	0.23

8. Discussion and Conclusion

The intent of this study was to investigate the impact of blended learning approach on Engineering students' learning experience and effectiveness. The study examined whether blended approach improved students' satisfaction and their achievement.

Though the comparison of achievement scores of blended learning and non-blended learning students yielded mixed results, the perceptions of students were in favour of blended learning. The mixed results were due to lack of effective online facilitation for engaging students in activities and interactive learning during the course; reviewing student discussion posts and completed course assignments and providing timely instructional feedback to encourage reflection and confirm learners' understanding. While designing, developing and delivering blended courses, faculty need to become effective facilitators and e- moderators in order to establish teaching presence online and to engage students in reflective, constructive, collaborative and social learning interactions and activities for improving students' online engagement, course dedication time and performance.

The results indicated that the RGUKT blended learning environment and teachers' practices provided the students with greater convenience; efficient use of time; access to multiple learning resources; flexibility, learning at their own pace; opportunities for reflection and interactions; and a combination of synchronous and asynchronous communication.

The study concludes that the results of the study were positive in many ways and provide the needed evidence to streamline and scale up the COL-RGUKT TEL initiative to build resilient education systems during crises. One avenue of further research is to correlate faculty online facilitation and student online engagement time with their achievement.

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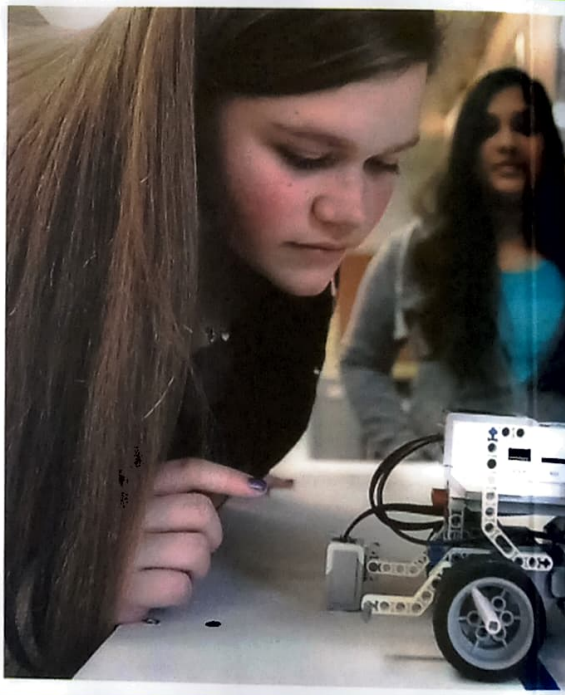
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