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

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

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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,

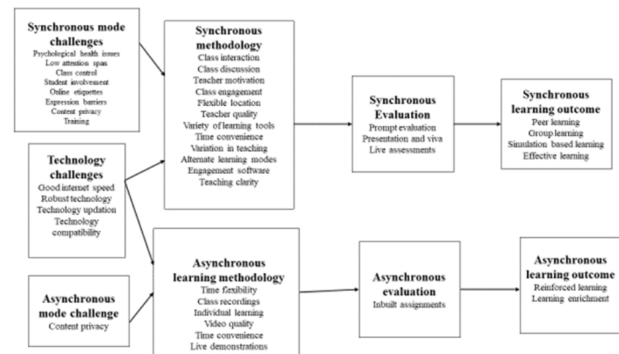challenges in implementation of models and technological challenges.

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