Implementation of ICAP Principles through Technology tools: Exploring the alignment between Pedagogy and Technology

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Abstract: Higher education institutions around the world have encountered unprecedented times in the year 2020 due to the impact of the COVID19 pandemic. All academic institutions were forced to an online mode of learning due to the sudden lockdown imposed across different countries to curb the growth of the pandemic. Faculty who were teaching courses had to radically change their pedagogy and adopt technology tools that could support virtual synchronous learning. In this paper, we explore one such effort where faculty at a private undergraduate engineering institution reimagined how they could apply and teach innovative teaching methodologies through technology tools. Faculty teaching engineering courses have to often utilize active and collaborative pedagogical techniques to help students achieve higher level cognitive outcomes and we describe how the same techniques could be implemented through online mode of teaching.

All the faculty prior to the start of the semester has undergone a 3-week faculty development program on technology-enhanced learning. During the program, the faculties were encouraged to identify technology tools that can be used to implement pedagogic techniques that are aligned to the Interactive Constructive Active and Passive (ICAP) framework. We describe in the paper the process followed by the faculty to align technology tools with the various pedagogies identified for the courses. We provide a list of various pedagogies by mapping them to the ICAP framework and discuss how the technology tools were used to implement them. The discussion in this paper will provide engineering educators with much needed insights on how to implement innovative pedagogies through technology tools. The results can be used by faculty as they transition to a blended mode of learning post COVID19.
Keywords: Pedagogy, Interactive, Constructive, Active, Technology, Canvas LMS.

1. Introduction

It is essential to strengthen the logic of the students by implementing the pedagogical techniques that are aligned to the Interactive Constructive Active and Passive (ICAP) framework. According to Bruner (1966), the essence of teaching and learning is to help learners acquire knowledge and use the knowledge they have acquired to create other knowledge. Technology has seen a great rise since the past decade. Suddenly the higher education institutions around the world have encountered unprecedented times in the year 2020 due to the impact of the COVID19 pandemic. All academic institutions were forced to an online mode of learning due to the sudden lockdown imposed across different countries to curb the growth of the pandemic. Faculty who were teaching courses had to radically change their pedagogy and adopt technology tools that could support virtual synchronous learning. This was a challenging situation to the faculty. The pedagogical principles had to be implemented by the technology tools.

Bosch & Cardinale (1993) indicated that while it is important for teachers to be provided with technological skill, it is also important to educate them on how to use that skill to support learning. All the faculties of KG Reddy College of Engineering & Technology prior to the start of the semester have undergone a 3-week faculty development program on technology-enhanced learning. Chi and Wylie (Chi, 2009; Chi & Wylie, 2014) developed a framework for categorizing different learning tasks in terms of what students are doing when they complete a task.

ICAP framework describes the elements of the class room. During the program, the faculties were encouraged to identify technology tools that can be used to implement pedagogic techniques that are aligned to the Interactive Constructive Active and Passive (ICAP) framework. The faculties were extensively given training on the Canvas Learning Management System (LMS). The ultimate goal of the FDP was to integrate the technology in teaching so as to enhance the learning of the students. The faculties have to reach the cognitive levels of the students and achieve the maximum learning by implementing the ICAP principles through technology. Technology integration is the integral part of instruction.

In this paper the process followed by the faculty to align technology tools with the various pedagogies identified for the courses has been described. For an effective teaching and learning the pedagogies aligned with Interactive, Constructive, Active and Passive had to be implemented using the LMS. This paper focusses mainly on the

implementation of the Interactive, Constructive, and Active principles of Pedagogy through the technology tool that is LMS CANVAS. This paper serves as a reference to implement the pedagogical tools for the various Engineering courses.

The following research questions are addressed in this study

RQ1: How the technology tools can be aligned to pedagogy during online mode of teaching?
RQ2: How ICAP principles are implemented through technology tools?

2. Literature Review

2.1 ICAP Principles

ICAP(Chi, 2009; Chi & Wylie, 2014). The ICAP theory provides an organizing framework for tracking cognitive engagement by monitoring students' overt behaviours and students' products during the learning activities. The theory suggests that levels of engagement can be reasonably inferred based on the observable actions of the students during learning activities as well as their products (which can be notes and/or diagrams students wrote, or their questions and comments, etc.) In this way, ICAP can serve as a tool for analysis of teachers' questions as well as helping the teachers assess cognitive engagement on the fly. The ICAP gives us four ways of engaging the students to reach the cognitive levels of them. This enhances the learning of the students as they can involve more in case of collaborative, co-operative which comes in the category of interactive learning. In this type of engaging the student there would be high peer to peer interaction which paves the way for increased involvement and learning. The interactive learning was implemented by adaptation of a "jigsaw" model (Aronson, 2002; Johnson, Maruyama, Johnson, Nelson, & Skon, 1981) Students first learned one of the three subtopics and then reorganized to peer-teach their subtopics to peers who had initially learned about other subtopics. While peer-teaching, or jigsaw, strategies are not inherently interactive in the ICAP framework, these adapted jigsaws required groups to solve high-level cognitive tasks requiring information from each student and thinking significantly beyond what any one student was given. Unlike the constructive activities, student interactions in the groups were structured through guiding prompts to maximize substantive exchange of ideas, a key element of interactive activities (Chi & Wylie, 2014). This method of jigsaw could be implemented by the technology tool that is LMS which will be discussed in the next sections. The ICAP principles can be implemented by the technology. These principles when implemented successfully through the technology then there will be enhancement in the online mode of teaching and learning.

When a faculty goes on lecturing and do not ask the students to do anything then the students are in passive mode of learning. Here if the faculty or the instructor intervenes and asks the students to take the notes, then the students will be actively engaged. In this case the students are just copying whatever the faculty is saying or writing on the board. If the students go beyond these notes and solve something taking reference from the class, then students are constructive. The difference between the active and constructive is that students' involvement is more in constructive as student will be thinking and solving or will construct something from the concepts learnt in the class. Examples of constructive are the faculty/ instructor is asking the students to solve a problem, give a logic and ask to write the whole program or for the given concept, ask the students to draw the concept map. The interactive principle is more similar to constructive; the main difference is in interactive the students have to work collaboratively with the peer to complete the given task. This also could be implemented using the technology. In interactive learning students have to co-infer new ideas, generate the questions and provide the answers to each other, group discussion is one of the examples of interactive learning. The students have to co-operate, learn from each other and derive the solutions.

2.2 Technology and Pedagogy

Technologies are neither neutral nor unbiased; rather, particular technologies have their own propensities, biases, affordances and constraints. Inherent attributes that make them more suitable for certain tasks than others (Bromley, 1998; Bruce, 1993).There has to be the alignment between pedagogy and technology. combining the knowledge of technology with their knowledge of content and pedagogy (Pope el at, 2002). The research studies have shown that instructors need to have a good understanding about how the technology should be integrated with Pedagogy and Content knowledge for effective classroom instruction (Gess-Newsome, 2002).

It requires understanding of proper framework to develop the same. The basis of this framework is the understanding that teaching is a highly complex activity that draws on many kinds of knowledge (Mishra, 2006). Renamed TPACK (technological pedagogical content knowledge), the combination of subject knowledge, teaching practices and technological knowledge "form an integrated whole 'a Total PACKage'" (Thompson & Mishra, 2008). In this paper the alignment of the pedagogy with the technology is achieved by using the LMS. Due to these unprecedented times it became obligation to align the pedagogy and technology. Bruner eloquently states: To instruct someone ... is not a matter of getting him to commit results to mind. Rather, it is to teach him to participate in the process that makes possible the establishment of knowledge. We teach a subject not to produce little living libraries on that subject, but rather to get a student to think mathematically for him, to consider matters as an historian

does, to take part in the process of knowledge-getting. Knowing is a process not a product. (p. 72).

3. Methodology

In this paper the process followed by the faculty to align technology tools with the various pedagogies identified for the courses has been described. The goal of the paper is to explore various educational technology tools to conduct pedagogical activities.

The list of various pedagogies is tabulated by mapping them to the ICAP framework.

ICAP Principle	Pedagogy	Technology
Interactive	Collaborative Learning	Break-out rooms in CANVAS
	Brainstorming	During Live class in CANVAS
	Learning by Teaching	Students presentations in CANVAS live session
Constructive	Flipped classroom	Material upload through LMS, brief discussion in the live class
	Assignment	Giving the assignment: Probability concept problem solving
	Problem - Solving	Students will be given the complex problem in the Live class room and they use their creativity and solve it.
Active	Minute paper	At the end of the class students are asked to write the points of the concepts taught in class and upload.
	Polling	Using poll option in CANVAS
	Public chat	Using the public chat option in the CANVAS

Table (i) Mapping of Pedagogy with ICAP principles and Technology.

The elucidation on how the technology tools were used to implement them has been given. The discussion in this paper will provide engineering educators with much needed insights on how to implement innovative pedagogies through technology tools. The various technology tools could be used to accomplish the ICAP principles of the pedagogies. Mainly in this paper the 3 principles of pedagogy has been mapped with the technology tools. Different topics from the Electronics & Communication Engineering were taken to implement the Interactive, Constructive, Active principles of pedagogy through technology. These are the activities which are to be conducted to enhance the students' learning.

1. Interactive: In this principle there is a dialoguing between two or more students on the same topic, the contribution has to be from all the members. Example could be discussing questions with peers or instructors. Entire team can solve the problem together with peer or instructor. The result of the interactive principle would be the best as students' increase their learning, co-operative skills. As the students are communicating with the peers or instructors, it reaches to the cognitive levels of the students which in turn increases the efficacy of the students.

A. Collaborative Learning: This pedagogy could be categorized under Interactive principle. It is learning in groups, by working together. In this type of pedagogical activity learners are actively engaged and learn from each other. It helps in understanding the concepts in a better way and learners' are able to synthesize the concepts.

Technology used to implement the collaborative learning is Breakout rooms in CANVAS. The topic that was chosen was Distribution Function & its properties. This topic deals with how the random – variable is distributed on the real axis, and the properties needs some discussion to realize the importance of all the properties. This distribution function could be applied to the bigger data set which is used in the data – science. This activity was implemented in the online class after brief overview of the same topic. The students were divided in to 8 groups, each group consisting of 3 or 4 students. The time given for discussion was 15 minutes. The instructor could visit all the rooms and also interact with the students. The students were discussing among themselves and inferring all the properties. The students wanted this type of discussions more when the instructor asked about the activity. The discussion among themselves lead to the deeper understanding of the concept. It was efficiently performed using the breakout rooms option in the CANVAS. The screenshot which elucidates how to create the break out rooms has been shown in the Fig (i)

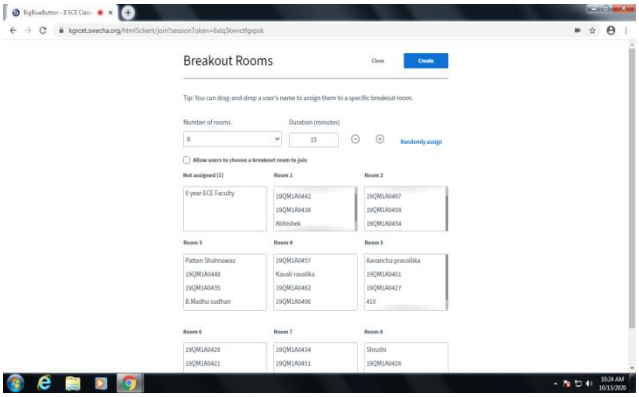
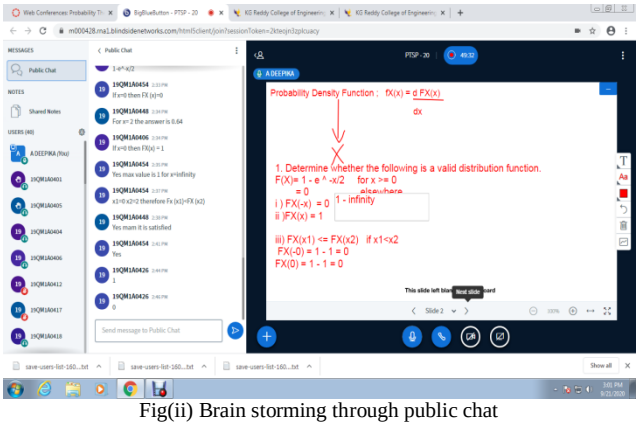


Fig (i) Creation of Breakout rooms

B. Brainstorming : This pedagogy will come in interactive principle of ICAP framework as there will be immense interaction between the learners among themselves and learners with the instructor. Here the list of ideas are taken from all the participants spontaneously. The entire learners are free to give their idea on a given topic. The topic that was chosen to implement brainstorming was Probability Density Functions. The question by the instructor was how a function could be called as the valid distribution function. Students gave their various ideas through the public chat option in the canvas. This method helped them to figure out the proper explaination when a function could be called as a valid. This assists the students to apply this concept to the major applications. The screenshot Fig(ii) Brain storming through public chat given below explains how the ideas could be collected by the public chat option in the canvas.



Fig(ii) Brain storming through public chat

C. Learning by Teaching : This pedagogy has been categorized as interactive because students are learning by teaching to the peers'. After the presentation the peer to peer and instructor to learners discussion was there which lead to the deeper understanding of the topic. The topic that was chosen was the " Indian/Swadeshi Microprocessors''. The students were given the topic one day before the implementation. They researched well about the topic and came preapared. The presentor role was given to the presentors and the students could upload their presentation and elucidate it to all the learners. The time limit given to present their microprocessor was 12 minutes, 3 minutes was fixed for the discussion among the learners. This mechanism assisted all the students to know about various swadeshi microprocessors and the implementation of these in their project based assignments in the embedded domain.

2. Constructive : In this type of principle the students go beyond the presented information, This principle is student centric where learners under go self – construction. The problem solving is one of the best example of this principle where students solve the given problem by themselves. Comparitively it is the better method to increase the deeper understanding of the concepts.

A. Flipped class room: This pedagogy is categorized under constructive principle of ICAP framework. In this method the material related to the particular topic would be given in advance to the students. The students are supposed to learn that topic and then in the class room only the important points could be discussed. This method was followed for the topic Number systems in the Digital System Design as the students had prior idea of this concept in the previous classes, when the students learnt the topic and came to the class. They became more perfect about number systems. The uncertainity that prevailed with the topic was completely vanished. In the canvas there is an option to add the modules where all the material could be added. The material regarding the number systems was also added which the students could refer before the class, which lead to the deeper understanding of the topic.

B. Assignment: This assignment pedagogy is categorized under constructive principle of ICAP framework. The students are given the problem solving type of assignment. In this case the student has to think themselves and by self – construction have to solve the problem. Assignment can be added as one module in the canvas course section. The problems on basic concepts of probability was given. The students solved them and submitted in the canvas. In this way construction principle of the pedagogy was achieved. The students could do self regulated learning and the deeper understanding of the concept was achieved by solving the problems which was given as assignment.

C. Problem solving: This pedagogy also comes under constructive principle of ICAP framework where in the live classroom the students were asked to solve the problem after the explaination of the topic Bayes theorem. The students were given the application oriented problem of communication system where the probability of transmission error has to be calculated. The students by self – construction thought themselves and solved the given problem in the live online class on a paper and then the students uploaded it in assignment module of the

canvas course section. The below screenshot Fig(iii) describes the live class room where the concept had been taught and the problem was solved by the students and submitted in the assignment module of Probability Theory and Stochastic Processes section.

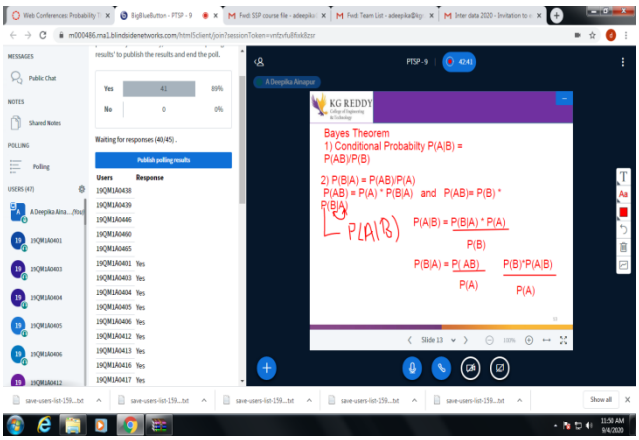


Fig (iii) Live classroom

3. Active: The active methods could be implemented in the online live classroom. Active principle of ICAP framework enables us to interpret whether the student who is in the online class is actively involved or not. We have various options in the LMS canvas which helps the instructor to actively engage the students. The students also become active by these methods.

A. Minute paper: This pedagogy is categorized under Active principle of ICAP framework. This is implemented in the live class room using the assignment option in the canvas. The topic chosen is Rules and Laws of Boolean algebra in Digital System Design subject. This topic was chosen to observe the ability of understanding and memorise and also know the depth of understanding of assigned topic which will be very useful activity for learners and it helps them in improving their time management skills. After completion of 20-25 minute of lecture, to observe the ability of understanding/memorise the students' knowledge asked them to write a minute paper within one minute of time. This activity helps the students' to be active in the class. The students submitted this one minute paper at the end of the class in the assignment module of canvas. In the below screenshot Fig (iv) Minute paper through Assignment is shown. It describes that students wrote on a paper and submitted in the Assignment section. In this manner this pedagogy can be accomplished using the canvas LMS.

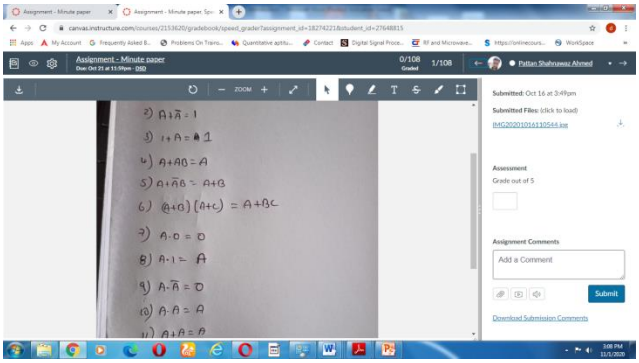


Fig (iv) Minute paper through Assignment

B. Polling: This pedagogy is specially used in the online live class room, to examine whether the students are concentrating in the class and are active or not. Hence this can be mentioned in the active principle of the ICAP framework. This could be implemented for any topic that is being taught in the class. In the middle of teaching a topic the question could be orally asked using the microphone or the question could be written on the white board and with the poll option in the canvas, the students will get the options on their screen and they can mark the option. In the below screenshot Fig (v) poll questions are written on the board and the instructor had clicked on polling option, various types of option orders will come. Depending on the question the poll options are selected. These options will be received on the screen of the students. The students can exercise the options. The students who are inactive can also be detected by this pedagogy.

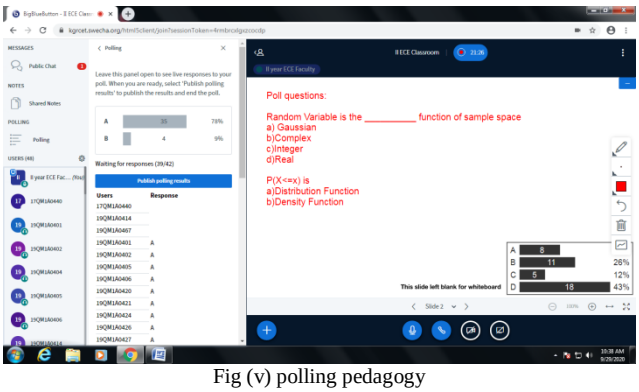


Fig (v) polling pedagogy

C. Public chat: This is also the online pedagogy which is categorized under active principle of ICAP framework. This could be used in the online class in any topic where the students will be answering the questions asked by the instructor using the public chat. In this manner all the learners' will be actively participating in the online class. In the below screenshot Fig (vi) the active participation of the students through public chat is depicted.

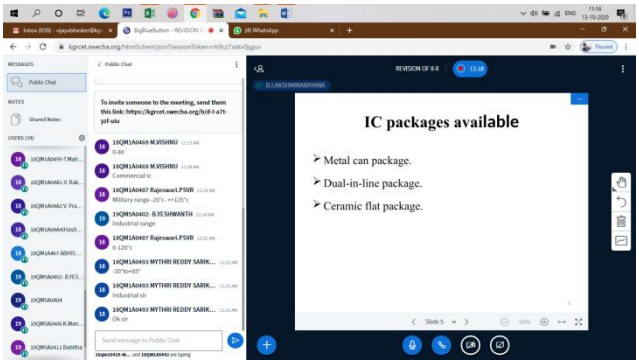


Fig (vi) Active participation of the students through public chat

4. Results and Discussion:

The list of various pedagogies by mapping them to the ICAP framework has been provided. The discussion on how the pedagogy could be implemented by the technology tools for three Electronics & Communication Engineering subjects was held in the methodology section. These methods of online teaching aligned with pedagogy and ICAP framework provides the engineering educators with much needed insights on how to implement innovative pedagogies through technology tools. Hence any pedagogy can be implemented online and learning efficacy is excelled using the technology tools. The Interactive, Constructive and Active principles are successfully implemented online using the canvas LMS and other technology tools. The pedagogies aligned with the ICAP principles as implemented in live classroom is also successfully implemented in the online classroom with the help of technology tools.

Fig (vii) live classroom group discussion and online group discussion using breakout rooms

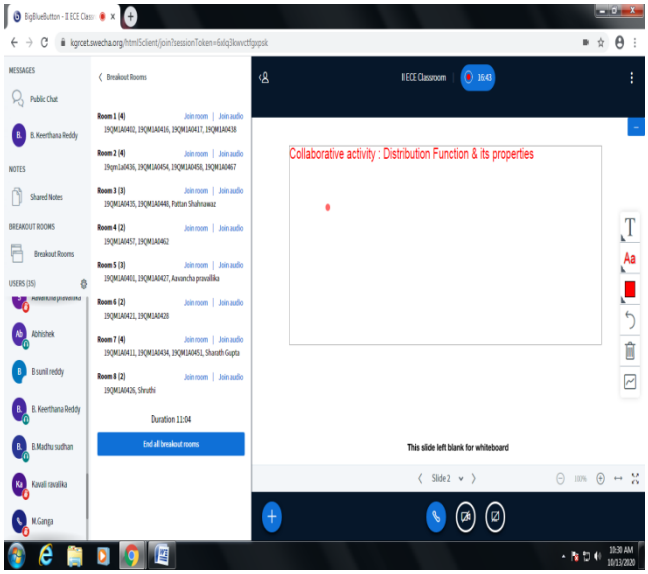


Fig (vii) live classroom group discussion and online group discussion using breakout rooms

Fig (viii) Live classroom presentation and online paper presentation by the student

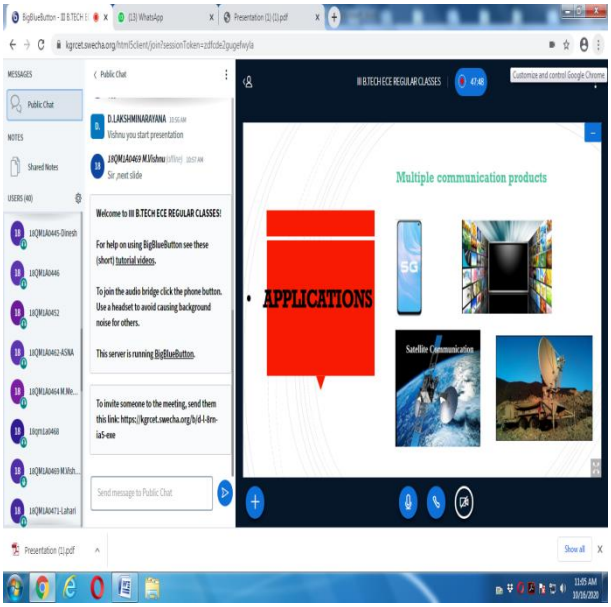


Fig (viii) Live classroom presentation and online paper presentation by the student

In the below screenshot group quiz was implemented through kahoot on the topic Random Variables and in the beside screenshot students have solved the problems on the white board using the multi – user window option. In this way all the pedagogies could be implemented in an online classroom. This paper as a result addresses the current COVID19 challenge.

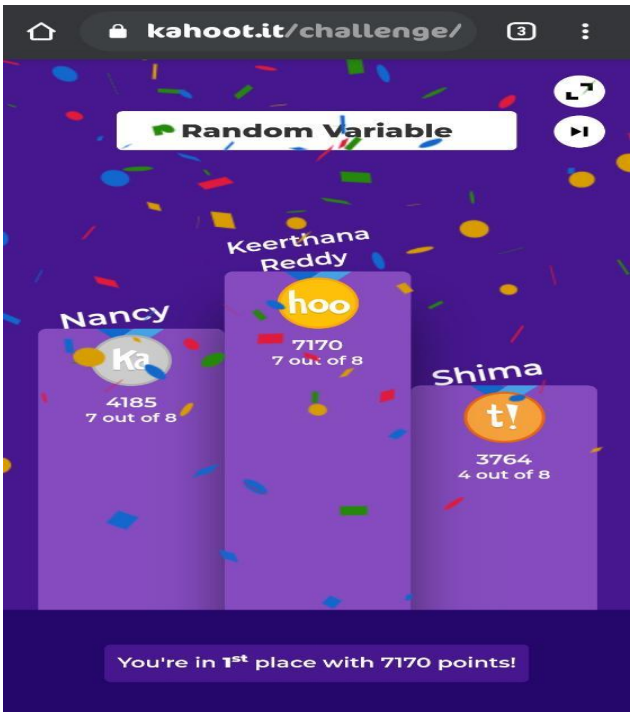


Fig (ix) Quiz as pedagogy through kahoot and problem solving by the students using multi – user window

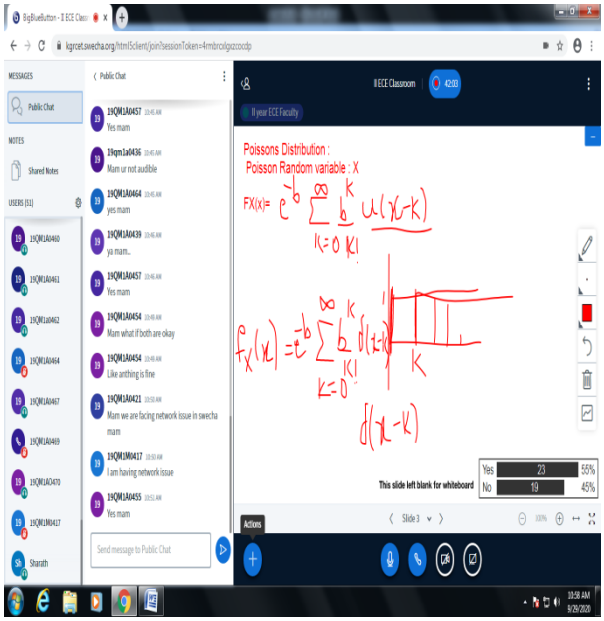


Fig (ix) Quiz as pedagogy through kahoot and problem solving by the students using multi – user window

5. Conclusion: The faculties at KG Reddy College of Engineering & Technology have successfully reimagined how they could apply and teach innovative teaching methodologies through technology tools. Faculties have implemented the interactive, constructive and active pedagogical methods to achieve higher level cognitive outcomes in the online mode of teaching during this pandemic situation. The list of various pedagogies by mapping them to the ICAP framework and discuss how the technology tools were used to implement them. The technology tools were implemented on the identified courses; Probability Theory & Stochastic Processes, Digital System Design and Microprocessors & Microcontrollers. The discussion in this paper will provide engineering educators with much needed insights on how to implement innovative pedagogies through technology tools. The results can be used by faculty as they transition to a blended mode of learning post COVID19.

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