Journal of Engineering Education Transformations,
Volume No 36, January 2023, Special issue, eISSN 2394-1707

10.16920/jeet/2023/v36is2/23012

Digital transformation of Industrial Automation Course in virtual learning environment during COVID-19 Pandemic

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***Abstract*— A learning environment is a diverse platform where users are engaged and interacted to learn new skills by any means of learning methodology. Nowadays the millennial students are fast learners and expecting a new learning environment and methodology to enhance their skills in learning and acquiring knowledge. Though they possess many good skills they are under various pressurized social and family environments due to COVID-19 pandemic which lead to get depressed quickly. The traditional teaching learning methodology is also increasing their stress. This stress will affect the cognitive functioning among the students and the mentors and further leads the students to hate their subjects and slowly reduce their involvement and interaction with subject instructors. To overcome the above problem, the instructors should have the responsibility to incorporate an arsenal of strategies that would inoculate learners against the negative attitude by providing enough positive experiences during this post COVID situation. The proposed work gives a brief description about the online and off line learning environments and their impact on the education with societal aspects. It collaborates the research from different traditions and gives description about the connections that can be drawn between the teacher-student interactions and with the peer interaction through case studies.**

***Keywords*— Virtual Learning Environment, Discord, Software learning, Post COVID**

I. INTRODUCTION

LEARNING environment is the most vital thing in which each teacher/professor should give the concern. Instructors should understand each student's state of mind and run through it, NRC (2000). A teacher/professor should make a student to feel very comfortable with the teacher which leads to the better training environment than the former. Creating a classroom environment remains another necessary aspect in current pandemic situation for encrypting a secure learning environment proposed by Alvarez et.al (2009). All scholars get to understand about what they need in common with their peer learners in online and offline studies. Current pandemic situation paved the way for all mentors to develop virtual and remote learning environment for all students. Another important thing is the responsibility of the teacher to develop a learning environment where students feel motivated to learn and practice within the boundaries of a secure classroom. Thus, the developing environment must be secure and engaging all students by introducing secure gamification tools like Jcross from hot potatoes, MCQ using Quizizz, Survey using Plickers and so on. Students from privileged backgrounds, supported by their parents and eager to learn, could find them well beyond closed school doors to alternative learning opportunities, Monterrat et.al (2013). Those from deprived backgrounds often remain excluded when their schools pack up. This crisis has exposed the various inadequacies and inequities in our education system from access to the broadband and computers needed for online education, and therefore the supportive environments needed to specialize in learning, up to the misalignment between resources and wishes. While the tutorial community has made concerted efforts to take care of learning continuity during this era, children and students have had to rely more on their own resources to continue their learning remotely through the web, television or radio. Teachers also had to adapt to new pedagogical concepts and modes of delivery of teaching, that they were not trained, Khalid, Fariza (2019).

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Some of the studies like Moos, Steele, and Bronfen Brenner present models of the relationship between environments and students' outcomes, reflecting the importance of the environment to learning. If we think about better conditions for teaching and learning in schools and classrooms, we might realize that a focus on the constructed environment and its possibilities would support teaching and learning. Reopening of schools and universities will bring unquestionable benefits to the students and therefore the wider economy. The E-platform collaborative learning creates team building among students. The webinars, e- courses like NPTEL, Coursera, Edx has created opportunity among the students to develop their skills. The transition rate among engineering courses drastically reduced due to collaborative and active learning approaches. The online learning platform across the academic world has grown rapidly during this Covid 19 pandemic period. Additionally, reopening of schools will bring economic benefits to families by enabling some parents to return to figure. Those benefits, however, must be carefully weighed against the health risks and the requirement to mitigate the toll of the pandemic,

"Learning environment cites to the various physical locations, contexts, and cultures during which students enrich their knowledge. Students may learn during a big variety of settings, like outside-of-school locations and outdoor environments, the term is usually used as a more accurate or preferred alternative to the classroom."

Horne-Martin, S (2002) mentioned the active learning can be defined as any activity involves students in doing things and develop their psychological skills. It focused on the transformation of education and their environment that happened during covid-19 crisis P. Rospigliosi (2020). The introduction of digital transformation in all universities provides wide exploration of current education in new dimensions. Distance/online education also has been a great mode of education during this pandemic which satisfied all the requirements of the students. Researcher stated that the Technology Enable Active Learning process (TEAL) triggered the students to enhance their skills to be develop in both cognitive and psychomotor level. The introduction of additional gadgets like simulation software, clickers initiated the digital learning among higher level education ecosystem. The development in education among the students by introducing co-teaching method for every subtopic in all the course syllabi. Fusic Julius (2021) proposed the peer learning and lecturing activity engage the students throughout the course. The author elaborates that the collaborative learning supported group activity made the students to practice and implement the theoretical knowledge effectively. The collaborative learning increases the knowledge sharing to solve complex engineering problems. The high-level cognitive skill can be established through collaboration among the students and the instructors. Researchers provides enormous platform to interact with the students to find out course content with advantaged tech and activities. Introduction of innovative learning tools and other ICT tools engage the students and create better learning ecosystem S. J. Fusic (2018).

Author further introduced mobile learning approach to interact with the students for improvisation of learning approach. Assessment of student activities using ICT tools was demonstrated. Blended learning with case studies in universities and explanation about pedagogical processes, adopt or implementation in fact development processes as mentioned in P. Rospigliosi (2020). "A new teacher, get your procedures in situ and teach those procedures a bit like you were teaching a math lesson, something that they absolutely need to learn to be ready to advance." Envision what every procedure seems like. What does it appear as if once they inherit the classroom from recess? Practice those procedures in your mind. Have that concept in your mind, then teach that to the youngsters. Model it to the youngsters." Collective self-perception that the teachers in a school/college should make an academic difference to their students, which can help them in their higher studies. Student centric lecturing approach must consist of gamification technique, active learning techniques and other interactive tools- mentioned. The figure 1 is an image for the learning environment from the teacher's perspective.

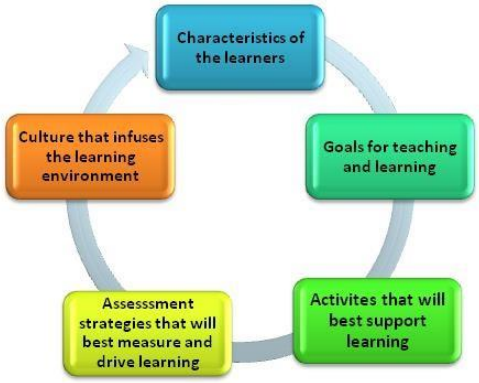

Fig 1: E-Learning environment platform for Teaching Learning Practice

II. PANDEMIC ISSUES, CONTROVERSIES AND PROBLEMS

The main contribution of the proposed work is to create novel learning ecosystem for an Industrial automation course with the following objectives: to overcome the internet connectivity issues, to provide secure and engaging ICT tools and Add-on usage, to create virtual and remote mode ecosystem and to increase the mental strength of the students and the instructors using case study.

A. Internet Connection:

One of the major challenges faced during the online learning platform is internet connectivity issues. Many students are from rural background and few students are from Kashmir (union territory region) where the internet connectivity is poor. In virtual audio and video mode students are not able to cope up with the instructor and other students due to poor internet connectivity and weak bandwidth issues. Each and every day, it was planned to conduct 4 -5 hours online class for different courses. This made the expiry problem of the students' internet package per day limit. Due to this many students had lost their connection in between the activity period. The connectivity issues are reduced by uploading PPT to rural and remote location students. The class session recorded audio is converted into mp3 file format and sent it to the students through WhatsApp or Telegram or other social communication applications as explained in Fusic S J (2021). This enables the students to spend only 5-10 Mb data to find the session and understand the concept easily. In some other cases the lectures are recorded and uploaded in the YouTube or google drive link in the Google classroom or Canvas LMS platform. During the availability of the internet connection and the data, students have downloaded the video and learn the concepts clearly.

B. Hardware gadgets:

Many of the Students are not able to buy a laptop or Personal computer due to their weak financial background. Using mobile phones students are not able to interface 32-bit or 64-bit software's like Pico soft, Fluidsim and Indra works are explained in Fusic et.al (2020). Many students are not able to have higher end processor mobile phones in which the lectures through Team or WebEx software are not supported. To overcome the issues, government announced free laptops with reasonable specification to all the schools and Polytechnic students. The management and other trustee people provide rental laptops and notebook to the college students to overcome the issues during pandemic condition.

C. Mental Strength:

Students are not able to concentrate online platform activities due to the online assignments given by the instructors of the other courses and the pre placement team members. The stress created during these hard Covid times are made the students to have some refreshment or change in their conventional learning practice. By conducting tutor ward meeting handled by the teacher and counseling sessions handled by the professional members created the chance to the students to discuss about their difficulties and to concentrate in their studies through online platform.

D. Virtual learning:

In this pandemic, virtual classes are conducted through many apps like Google meet, Zoom, Microsoft team etc. Some of the E-learning websites are google classroom, kahoot, quizlet, scratch, Canvas, Google chats rooms and Moodle mentioned in Fusic et.al (2022). They facilitate the way of teaching as well as learning which play an important role in learning environment. Due to this the online mode of learning has also been common among everyone now. It ensures a minimum safety distance between wards and staff, which usually depend on many factors such as classroom size, room availability, and the number of pupils per class. According to our knowledge, the effectiveness of the teaching learning process can be realized by having the face- to-face communication. But this couldn't be achieved if the Teaching Learning Practice (TLP) has been done in virtual mode. However, due to Covid Pandemic, most of the universities and educational institution prefer various learning platforms for students learning activities and assessments. These are useful in the case of theory classes, but when it comes to practical courses the virtual or remote mode of access to the college resources is quite complex. Hence, a classroom simulation may be a has become one of the methods of teaching/learning or evaluating the learning of curricular content that's supported an actual situation. The simulation is designed in such a way to model a real-life situation as closely as possible, by having the students assume roles as they analyze data, make decisions and solve the issues inherently within the situation.

E. E-Learning Platforms:

As stated by Hao, et.al (2020) the introduction of active learning in engineering courses made the students to obtain deeper knowledge about the course and its concepts. Thus, conventional learning environment is simple way of teaching with chalk and board. Horne-Martin, S (2002) discussed how systematic traditional education is, it can still fall into error. People desire to stick in to a system, but they always attached with their own predisposition that deviates from it. This shows very much in the glaring incidents that occur in traditional schools. To develop a complete learning environment for the students in a specific course or program is probably the most

creative part of lecturing. Since there is a tendency to focus on either physical institutional learning environments, or on the technologies used to create online learning environments, learning environments are wider than the physical components. The figure 2 showcases the virtual platform component implemented in the learning environment.

Fig 2: Knowledge centered ecosystem for students

III. TYPES OF LEARNING ENVIRONMENT:

The word 'learning environment' cites to the way a classroom environment is set up. Learning environment can be set up in a traditional mode or virtual mode or blended mode. The three types of learning environment based on classroom surroundings are face-to-face, online, and hybrid. Teachers can include active learning into their most popular format, the lecture, by using the Modified Lecture, Bonwell (1991).

A. Face-to-Face

Face-to-face or conventional learning occurs through an eye-to-eye contact of the individual persons. This means that assignments, discussions, and the other activities occur in the classroom are under the direction of a lecturer. Some of the characteristics of a face-to face learning environment are:

1. Learning occurs continuously in real time. This allows students to ask questions and get immediate feedback.
2. The lecturer is the head of the class, guiding students through lessons. This is beneficial because students get one-on-one guidance, and it allows for differentiated instruction based on the students' needs.
3. The teacher and the students engage themselves in personal communication regularly. This permits teachers and students to forge relationships and build trust.

B. Online Learning mode

Online learning occurs through an internet-based platform. The teacher sets up lessons and assignments ahead of time, and students should complete them independently. Some of the characteristics of an online learning environment are:

- Learning can occur asynchronously. This means that the students can log in to the online classroom at any time, irrespective of the start time of the class.
- Students can work at their own pace based on the set due dates by the teacher. This allows for student independence and reinforces student responsibility by placing the onus of work completion.
- Students can reach out the teacher (usually via email or phone) if they need assistance. Teachers are accessible to answer the questions and respond to students' concern. However, there may be a delay in response time, depending on the teacher's availability.

C. Hybrid learning

Hybrid learning utilizes both face-to-face and online learning environments. Students are scheduled to attend the class in-person, but are also required to do the assigned work independently through online. Some of the characteristics of a hybrid learning environment are:

1. Many colleges and universities are now offering the additional online support services like online library access, online academic advising, online tutoring and online bookstores to the students.
2. The goal is to minimize how much time a student must spend for their on-campus learning.

Learning environment may vary from classroom to classroom and context to context. There is other four types of learning environment, based on the way of teaching learning methodology and with unique components. Learning environment can be They are student-centered or learner-centered; knowledge-centered; assessment-centered; and community-centered environments. Figure 3 shows this classification.

D. Knowledge-Centered Environment

Knowledge-centered environment focuses on helping students to learn the concepts with deep understanding so as to use it in the new situations and contexts. Teachers in this environment believe that the rote memorization does not lead to true understanding and only helps the students to learn at the surface. Deep learning involves learning through problem-solving. An example of this type of learning environment is one where a teacher directly teaches a concept, such as how to find area and perimeter of a given square. The teacher would then take this concept one step further, connecting this new knowledge to a real-life scenario.

E. Assessment-Centered Environments

To be effective, learning environment must also be assessment-centered, which emphasize the importance of feedback to learning. Students need opportunities to get feedback so that they can revise their work. Assessments must match the learning goals. Formative, or classroom assessment, used to improve teaching and learning, is a constant source of feedback throughout the context of a course. Examples include teacher comments on work and quick checks for understanding in the classroom. Summative, or end-of-unit or course assessment, measures what students have learned by the end of a period of learning activities. Examples include state-wide assessment tests and teacher- made end-of-unit exams.

F. Student or learner centered learning environment

A student-centered classroom, or student-centered learning

environment, is the one where the focus of instruction is shifted from the teacher to the student, with the end goal of developing students who are autonomous and independent, by giving the responsibility of learning in the hands of the students. Many proponents of student-centered learning would argue that it's one of the most effective ways to help the students to develop the skills required for the independent problem-solving and lifelong learning.

G. Community centered learning environment

1. Community centered learning focuses on the interaction to the surrounding environment.

2. Community centered the online based learning should be understood broadly. It could be classroom, degree or school to which students, teachers and administrators feel connected to the larger community of homes, business, states and the nation.

3. The norms and expectations play an important role in the classroom and school communities.

Fig 3: Community centered learning environment

IV. ALTERNATIVE LEARNING ENVIRONMENT DURING THE PANDEMIC 2020

In general learning environment is meant for a face-to-face communication. This face-to-face communication couldn't be realized if the virtual communication is followed in the teaching learning process. In 2020, during the Covid'19 pandemic, it affects the routine process of many people's life. The pandemic disease becomes more of a threat for old people and people with health issues. The rapid spread of corona virus has led to lakhs and lakhs of death, financial crisis in small, medium and large-scale industries and lack of GDP growth and currency value. During the rapid spread the death rate was increased because of lack of awareness, careless attitude of the public and not having the vaccination for this virus. To control the rapid spread of the virus, Government announced complete lock down for the whole country and hence the online learning environment was emerged among the schools, colleges and universities.

The selection of learning ecosystem during pandemic condition was too complicated. The instructor has to follow the student pace in online mode and also engage them with new interactive education tools. Due to the pandemic crisis, leverages are offered to the students particularly for south Indian students. One among them was a decision taken by the government to pass the students even without writing the exams which endangered the online education system. To overcome these issues many universities and higher education sectors introduces digital transformation in learning. The digital learning platform includes secure and high-quality education. On the negativity of introducing all sessions as online classes, health issues like eye problems, headache and obesity problems and psychological problems were raised. As one of the solutions to address these issues the class hours are reduced to 2 hours per day. Even introduction of blended learning method of virtual and remote mode education provides appropriate safety and increase the quality of education. Also, the conduction of formative and summative tests through the college website link or LMS platforms assures the security on assessment activity. Furthermore, few higher education institutions use proctoring mode where the camera will be turned on when students start writing the exam and throughout the exam students were monitored by the invigilators. The disadvantage is that people residing in remote villages were suffered due to the poor network connection. To ensure the continuity of education despite of the lockdown, educational institutions have sought to use technology and offer online classes and learning experiences as an alternative for in-class time. However, many universities are struggling and lacking the experience and the time they needed to conceive new ways to deliver the instructions and assignments. Writing examinations were also affected, causing disruption to students' learning trajectories and progression. Although many higher education institutions offered online courses before the pandemic, few students considered it as the sole alternative to in-person learning. For example, in the United States, only 13% of first-cycle tertiary students are exclusively enrolled in distance education courses in 2017 (NCES, 2019). Other measures are also helped the students to learn at home. For example, the government has set up a new support system for the students and their parents for homeschooling (OECD, 2020).

V. CASE STUDY ON THE COURSE "INDUSTRIAL AUTOMATION"

Industrial Automation (subject code: 18MT520) is a 3-credit course offered by the Department of Mechatronics Engineering in Thiagarajar College of Engineering, Madurai, Tamil Nadu, India. Industrial automation is the replacement of computers and machines to that of human thinking referred in Fusic et.al (2020). The Industrial automation is a course that deals with the set of technology and automatic power devices that result in the automatic operation and control of industrial processes and machines without significant human intervention and achieving superior performance than hand control. These automation devices have the elements such as Human Machine Interface (HMI), Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) etc., as shown in the figure 4.

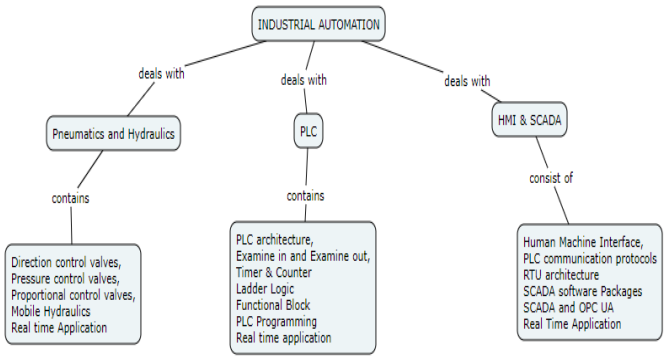

Fig 4: Concept map for 18MT520 Industrial Automation course.

TABLE I
18MT520 INDUSTRIAL AUTOMATION COURSE OUTCOME MAPPING.

CO No.	Course Outcome Statement	Weightage in %
CO1	Interpret the selection and programming methods of different automation components like PLC, SCADA, DCS and communication buses.	20%
CO2	Illustrate the construction, working and control strategies of different industrial drives and valves.	20%
CO3	Design pneumatic and Electro pneumatic circuits for given industrial applications.	20%
CO4	Design Hydraulic and proportional hydraulic circuits for given industrial applications.	10%
CO5	Construct a program using PLC and communication protocols to solve problems relate to industry 4.0.	20%
CO6	Select suitable automation system for given Industrial application.	10%

The course outcome for the CDIO framework Industrial Automation course is explained along with assessment weightage in table 1. The Table 2 detailed about the mapping with program outcomes and program specific outcomes with course outcomes to find the cognitive level. PLCs, HMI, SCADA etc., and technologies include various industrial communication systems. Due to the pandemic, the teachers felt it difficult to create a learning environment to conduct virtual learning over conventional learning activities in different ways. The case study deals with the CDIO framework of Industrial Automation course.

TABLE-2
MAPPING OF PROGRAMME OUTCOMES & PROGRAMME SPECIFIC OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	L	L	-	-	-	-	-	-	-	-	L	L	-
CO2	-	L	L	-	-	-	-	-	-	-	-	L	L	-
CO3	S	S	S	M	S	-	-	-	-	-	-	M	M	M
CO4	S	S	M	S	S	-	-	-	-	-	-	M	S	M
CO5	M	M	M	M	S	-	-	-	-	-	-	M	S	S
CO6	L	S	S	M	S	-	-	-	-	-	-	S	S	S

A. TPS strategy:

T (Think): The lecturer asks a specific question about the given topics. The students "think" about what they know or what they have learned, and come up with their own individual answer to the questions.

P (Pair): When the teacher asks another question, related to the previous one, that is suitable to deepen the students' understanding of the depth of the topic, each student is paired or grouped with another student. They share their knowledge with each other and proceed with active learning.

S (Share): Students share their thinking with the entire class. Teacher moderates the discussion and highlights the important points. In each semester, the teacher will conduct active learning sessions using pickers, quizzes, circuit design, dumb charades, and mono act. But during the corona period, these things couldn't be implemented but the same can be done in the virtual sessions through many applications which we realized later Raba, A. (2017).

TABLE-3
CASE STUDY ON TPS ACTIVITY IN 18MT520 COURSE

Course Case study: Industrial Automation Topic: PLC Programming -1
Target Students: Engineering V year (Mechatronics Engineering)

Think Pair Share - [30 minutes]
Problem: Due to Covid 19 lockdown, most of the lectures are done using virtual mode platform. During that period the interaction between the students and the instructor through eye-to-eye contact as like conventional classroom was missed. Using Gmeet and Zoom platform the lecturing methodology was modified as online teaching. In this session, the given problem statement is to convert Boolean equation into Ladder logic expression. Each student has to convert their own Boolean equation into virtual whiteboard output as well as Picosoft simulation output.

Thinking Phase (5 min): It is like brainstorming and morphological activity. What instructor does- He will allocate each equation to the students and asked them to recollect the previous class session and lectures to recap and solve the Boolean equation into Ladder logic circuit.

Pair Phase (10 min): Question: In virtual mode the interaction tools like Discord (as in figure 6) and Zoom which encourage the students to pair with random selected co student and discuss about the equation conversion from Boolean to ladder logic. Faculty asks for volunteer students to create private room in discord application and instructor control all private room on discord as mentor. Now students one by one interact with those volunteers in discord private room and then join with mentor to share their thoughts. Finally, the interaction gives clear idea about the concept.

Share Phase (15 min): During the pair phase the knowledge was shared between the students in a private room. In this phase all the students joined in public room option in Discord and shared their answers through jam board tool or canvas whiteboard tool. All the students can equally highlight about the given problem and the discussion on the solution for each problem which are
discussed privately. Thus, the usage of interactive tool reduces the additional time for sharing solution to particular problem alone.

What Instructor Does – Finally the instructor validated the solutions discussed in both private pair phase and share phase. Once the answers are discussed he/she gives time for the paired students to solve the problem using simulation tool in the second round of TPS activity.

TABLE-4
CASE STUDY ON TPS ACTIVITY IN 18MT520 COURSE IN VIRTUAL MODE

Course Case study: Industrial Automation
Topic: PLC Programming -2 (Virtual Simulation) Tools: Discord, Picosoft
Target Students: Engineering V year (Mechatronics Engineering)

Think Pair Share - [30 minutes]
Problem: In TPS phase -1 the solved ladder logic problem has to be designed and simulated using Picosoft PLC simulation software.

Thinking Phase (5 min): Initially students need to recollect all the step-by-step procedure to design and simulate the Ladder logic in Picosoft software tool. Picosoft is a PLC simulation tool used to design ladder logic, functional block diagram for the given logic and interface with real time PLC to perform the simulation cum hardware. Students can simulate online also with free education license to all the students for the limited period. In thinking phase, students can open simulation tool and check for step-by-step solutions.

Pair Phase (10 min): Question: The solved logic diagram in phase 1 can be drawn in the Picosoft diagram. Based on the requirements the PLC model is created with the ladder logic and simulated in discord dashboard in private room. Instructor enters into the discord private room and check the simulation model. If any error occurred in simulation, instructor may correct it in each private room. Now the students can interact with co students one by one, in discord private room and screenshot the results. Finally, the interaction gives clear idea about the simulation concept.

Share Phase (5 min): During the pair phase the screen shot of the simulated results are shared in general chat room. Instructor along with other students understands the solutions. The screen shot solutions are discussed with jam board or canvas white board drawn circuit for assessment and conclusion. During this phase all students can ask their queries about the solution images. Instructor also asks certain viva questions related to the screen shot solutions. Thus, the usage of interactive tool reduces the additional time for sharing solution to the particular problem alone.
What Instructor Does – Now in phase 2 the instructor compare the results of phase 1 with phase 2 and validate the marks in front of the team mates. At the end, the instructor correlates the real time industrial application with the students' solution. Thus, the TPS activity is concluded and the students improved their peer activity knowledge as instructed in the syllabus.

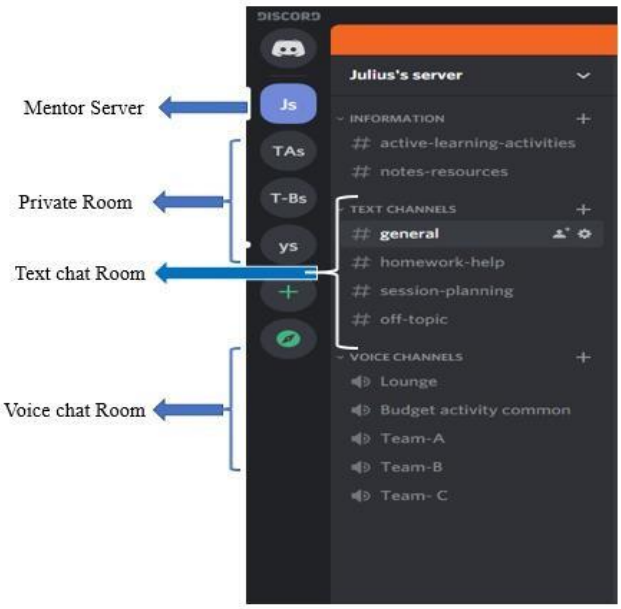

Fig 6: Discord Application dashboard

B. *White board lecturing mode*

During the classroom teaching inside the campus, black boards are used effectively for making the students to understand and learn. But when we come to online education, there is a need for a board to substitute the purpose of black board. Hence, we use this canvas white board to draw circuits, write equations and also, we can make the students to draw and practice in it for the circuits used in simulation. Instructor can also write the equations in the shared power point presentation (PPT) which is less effective than Canvas. In Canvas, the instructor can edit the size, colors and so on. As similar to the Canvas white board, the google extension Jam board do the same task but in an advanced manner. During G-meet video lecturing session, the instructor can use jam board in parallel with presentation. The figure 7 and 8 represent the lecture session handled through canvas white board.

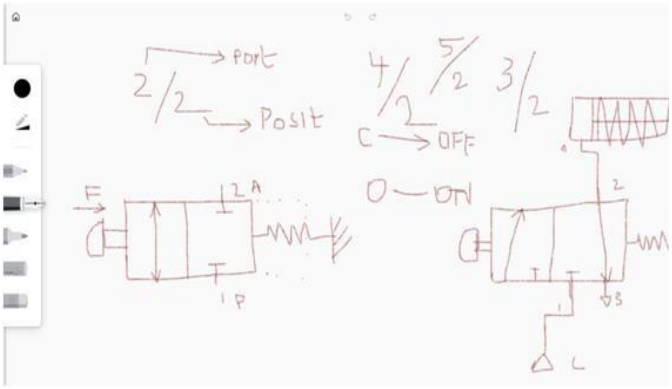

Fig 7: Canvas Whiteboard tool usage for pneumatic concept explanation

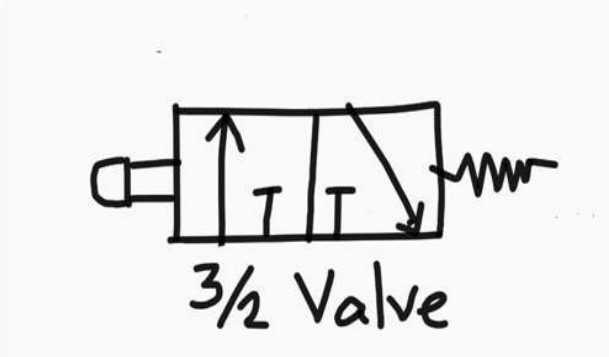

Fig 8: Canvas Whiteboard tool usage for Symbol demo

C. *Digital smart board:*

As like white board the remote accessible board is also used in lecturing the Industrial Automation course for the students. The introduction of blended mode in certain classes are assessed in remote mode operation as shown in the figure 9. Teaching by using smart board attracts more attention from the students and at the same time it makes teaching very interactive and innovative. Digital board is found to be very much useful in teaching/explaining the concepts (eg: working of three phase-controlled rectifiers) by using different colors to draw the phase and line-to-line waveforms. Annotation was another feature in digital board which creates the flexibility of using many layers, simultaneously answering the questions from the students and explaining the content on the same board. Whereas on PPT, it is like a rigid system, and the separate white board should be used for the explanations. The electronic white smart board was found to be very useful for lecturing in the class without boring the students as instructor can mix up the features like annotations and highlighting including drawing figures on to the document (imported from pen drive) using stylus with different tips. This would have not been possible in the LCD projector. Digital board offers a facility to save the lecture contents as .iwb file format, and in the next class it can be accessed to continue the lecture where it was stopped in the last class. Really this feature is amazing and the students were able to recollect all the contents of previous class lectures regularly. Even the students with different learning capabilities experienced the benefit of the digital board. Using Forms feature in digital board, instructors might do peer interactions like Think-Pair-Share activity, Brain storming, Polling for quiz activities etc. Using Remote PC feature in digital board, the instructor can access cloud server or remote personal computers from the laboratories. Using this feature instructor can explain and simulate complex lab experiments in class itself like Virtual Lab. The special feature is displaying questions for examination which reduce the usage of paper and also enhances the execution of the examinations (like adding Video or audio file in the question or animation in any particular questions). Running screen recorder software on the laptop with microphone enabled and screen share to the smartboard, use of inbuilt Microsoft Note to write on the screen using stylus, the

whole lecture contents with teacher's voice will get recorded and the video lecture is ready without camera. The hand written material using digital board can be converted into PDF and the instructor can store it in Impartus Backpack and share it with the students for future reference.

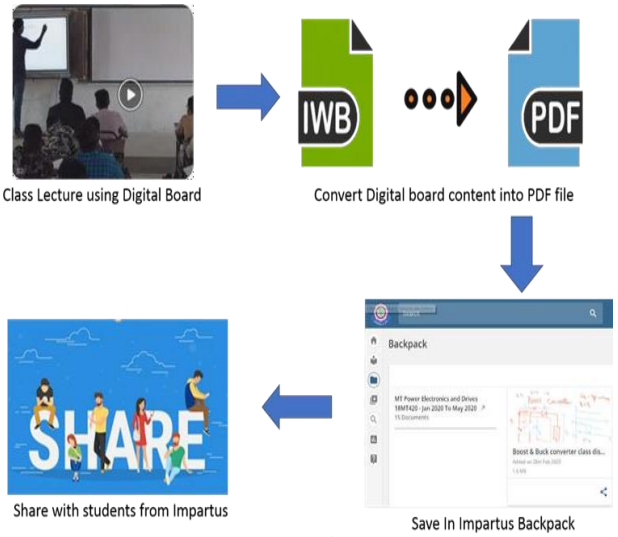

Fig 9: Digital smart board for industrial automation course

VI. LEARNING USING SIMULATION WITH OPEN-SOURCE SOFTWARE:

A classroom simulation may be a method of teaching/learning or evaluating learning of curricular content that supports an actual situation from the article Bicen Huseyin et.al (2022). The simulation is designed in such a way that it should replicate a model of a real-life situation as closely as possible, has students assume roles as they analyze data, make decisions and solve the issues inherent within the situation. As the simulation proceeds, students answer the changes within things by studying the final consequences of their decisions and their subsequent actions and predicting future problems. During the simulation, students will perform the tasks that will enable them to learn and evaluate their learning. An advantage of this method is that situations that aren't conducive to a system dynamics simulation are usually discovered within the initiative (choosing attention). The most common problem is that things are predicated upon a series of discrete events instead of a small number of stocks.

This Industrial automation course was lectured in 2020 odd semester through online platform. To engage the students for one- hour class, it was segregated into 30 minutes lecture and remaining 30 minutes demo or simulation explanation for the various sub topics. It was effectively done using the simulation. The real time application was simulated and shown to the students. During the class hours, the assignment was also given so that the students can bring their own unique circuits to troubleshoot the problems given by the instructor. The simulation software platforms practiced for this course are as follows,

✓ Picosoft (For PLC Programming and Ladder logic simulation)

✓ Fluidsim Pneumatic (Used for Pneumatic circuit simulation)

✓ Fluidsim Hydraulic (Used for Hydraulic and proportional circuit simulation)

✓ Indra logic works (PLC and SCADA virtual hands-on)

A. PICOSOFT:

Picosoft was specially created to help hardware developers build circuit diagrams for Pico controllers. The program is used to simulate these diagrams to find possible errors and calculate the controller output. The Picosoft simulation software is developed by Rockwell Automation for Allen-Bradley make PLC. This software lets the students to create, simulate, document, and communicate with hardware PLC using RS-232 communication protocols. The Picosoft provides a user-friendly, intuitive environment for industrializing controllers program in ladder logic and the functional block diagram. It is easy to transfer the controller program circuit diagram to the device. Figure 10 explains the Picosoft simulation.

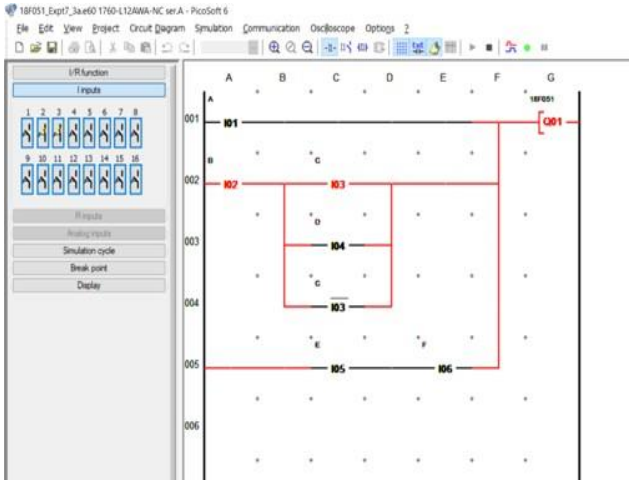

Fig 10: Picosoft PLC ladder logic simulation demo

B. FLUIDSIM PNEUMATIC:

FluidSIM is a software that provides complete platform for the creation, simulation, generation, instruction and demo study of mechanical pneumatic, electro-pneumatic, conventional hydraulic, electro-hydraulic, mobile hydraulic, proportional hydraulic, digital and electronic circuits. The program functions designed in Festo Fluidsim software as shown in the figure 11 interact smoothly, combining diverse media forms, library files and the blocks. This simulation tool increases the confident in understanding the concepts like fluid power automation. Using this software, students increase their skills and improve their self- study. In CDIO course framework, the lectures supported by the demos and simulation activities enhance the students' knowledge in the course and develop their skills about the course. Most of the assignments and lab activities are done using Fluidsim and Automation studio virtual software.

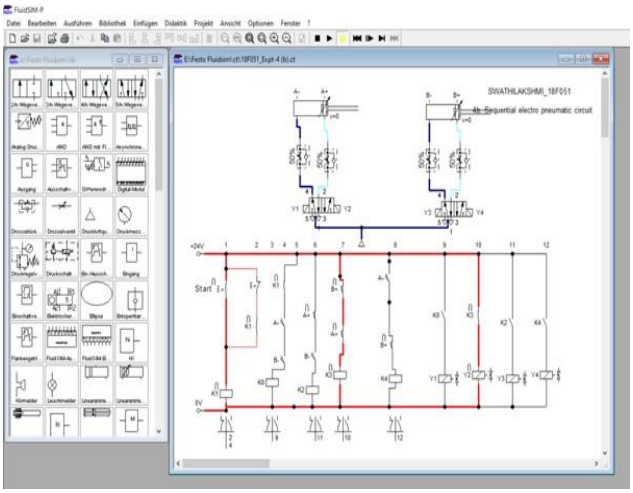

Fig 11: Fluidsim pneumatic circuit simulation demo. (Cite: https://www.festo-didactic.com/int-en/learning-systems/software-e-learning/demo-update)

C. FLUIDSIM HYDRAULIC:

FluidSIM Hydraulics is actually a teaching tool for simulating hydraulics-based circuits and runs using Microsoft Windows. The development of industry 4.0 is with advanced applications like mobile hydraulics and proportional hydraulics circuits. The industrial concepts are simulated and interfaced with hardware using these simulation software as shown in the figure 12.

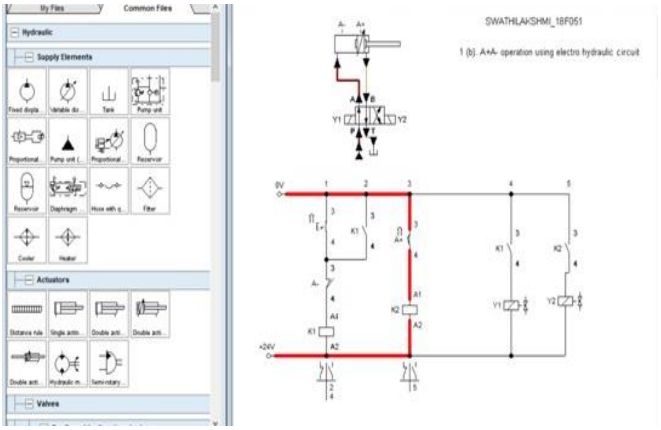

Fig 12: Fluidsim hydraulic circuit simulation demo (Cite: https://www.festo-didactic.com/int-en/learning-systems/software-e-learning/demo-update)

D. INDRA LOGIC WORKS:

The Indra Logic PLC solutions are based on the scalable Indra Control L control platform. It is also available in a uniform and compatible design for any applications in different performance classes. Their compact and good construction with terminal technology and simple DIN rail mounting makes them suitable for every type of automation environment. The Indra logics software can be interfaced with Rexroth Bosch PLC and servo control system. Figure 13 explains about this software.

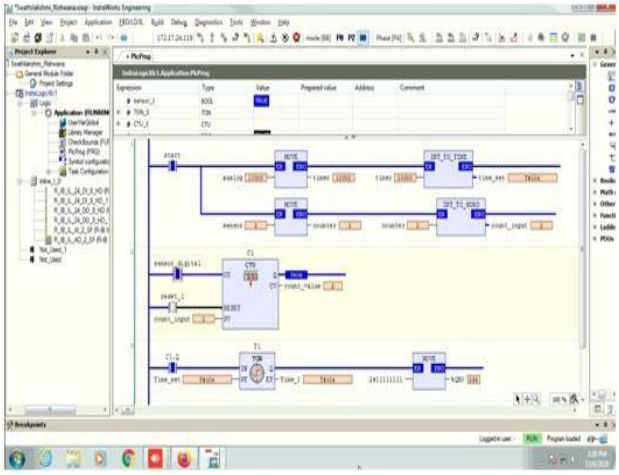

Fig13: Indra logic software virtual simulation demo

An application was given to the team members. They were instructed to design a circuit and make the lowest possible budget. Those who make the lowest budget will be the winner of that round. The team members can discuss through Discord App and at last they have to present their circuit and prepare a report. Figure 14 shows the flow diagram to conduct this activity.

Fig 14: Flow diagram for conducting Circuit design in virtual mode

VII. ASSESSMENT RESULTS AND DISCUSSION

Students enrolled in the Industrial Automation course were evaluated using rubrics and peer reviews, to measure their perspectives toward the proposed skills and their capacity for empathy. Three experimental batches (B) of strength of 40 are selected and the selection of group is in heterogeneous mode in each class. Gamification techniques are used continuously in 8 periods for B1(2020) which covers a complete module- Design of Electro Pneumatic circuits as given in the proposed case study. The same questions designed for Batch 1 of on-line mode were asked to the students of B2 (2020) and responses were noted in the class notes and assessed based on the observation of the teacher. The same questions are provided as assignments for B3 (2020). The performance of the three EGs in the summative assessment is recorded. Based on the Bicen Huseyin

et.al (2022), the summative assessment questions are different but based on the learning by doing online activities increases question responses. The responses and grades of each batch students are compared using one tailed T test hypothesis and it was observed that the students with online gamification activity scored good marks. Figure 15 shows the comparative results. Table 4 and table 5 give the hypothesis and T test results.

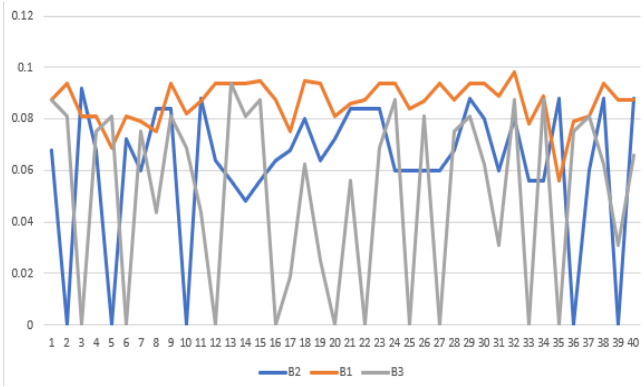

Fig15: Comparative results of three batches B1 B2 B3

TABLE-5
HYPOTHESIS RESULTS OF ALL THREE BATCHES

	B1	B2	B3
MEAN	38.345	37.284	30.1
SD	4.987	5.142	6.754

TABLE-6
ONE TAILED T TEST RESULTS

S.No	Compared groups	T test - value
1	B1 &B2	0.030124
2	B2 &B3	0.07514
3	B3 &B1	0.00074

With the feedback provided by the students as stated in Table 7, the Mann Whitney U test is run to see whether there is a substantial difference between the input provided by the three groups of students, with the null hypothesis being that there is no significant difference.

TABLE-7
STUDENTS FEEDBACK COMPARISON BASED ON MANN WHITNEY U TEST

Course Feedback	***t*-value**	***p*-value**	***p* significance *at p* < .05**	***Batch 1 %***	***Batch 2 %***	***Batch 3 %***
Excellent	- 2.70	.0170	*Significant*	*38.7*	*34.8*	*38.71*
Very Good	-4.94	.0002	*Significant*	41.3	31.9	41.39
Good	2.48	.0264	*Significant*	*15.2*	*23.8*	*15.66*
Fair	16.07	.00001	*Significant*	*4.64*	*9.26*	*4.24*

The observation indicated that Gamification activity-based students group develop their abilities or areas of interest towards automation skills, while other batch students do so during their final assignment session for development of skills.

VIII. CONCLUSION

The proposed approach ensures that education does not have any specific environment to accomplish during hard times. It can be accomplished anywhere with everyone's enthusiastic nature. Therefore, as we are entering into the COVID-19 recovery phase, it will be critical to reflect on the role of educational systems, particularly vocational education. The aim of the article is to motivate the instructor to select activity-based learning environment to engage the students and relieved their mental stress during the pandemic crisis. This has helped to restore a way of esteem for those workers who have worked relentlessly during this point to stay economies afloat. The outlook is very uncertain. Disruptions on the size we've just witnessed aren't limited to pandemics, but can also result from natural, political, economic and environmental disorder. So, through their role in developing the competencies and skills needed for future society, education systems will need to be at the heart of this planning. Based on the hypothesis results, the impact of the on-line learning by doing activity is less progressive but in the upcoming days all the instructors will adapt this methodology and the students will be encouraged to learn the content in secure and online mode. This includes rethinking of the evolution of the economy to guard against adversity, and defining the skills, education and training required to support it. Real change often takes place in deep crises, and this moment holds the likelihood that we won't return to the established order when things return to "normal". The current crisis has tested our ability to affect large-scale disruptions. It is now up to us to create as its legacy a more resilient society.

ACKNOWLEDGMENT

The authors would like to acknowledge the support of Thiagarajar College of Engineering, Coimbatore institute of Technology and KLN Institute of Engineering in the production of this work.

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